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JOURNAL

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Volume 16

Florida and Louisiana Divisions

June, 1996

ASSCT

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Volume 16
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J.C. McBurney. Emissions Control Design Criteria for Bagasse Fired Boilers

Michael J. Davis, Phillipe Rott, and Dean W. Gabriel. Development of a PCR Assay for Diagnosis of Leaf Scald Disease in Sugarcane

Charley Richard, Wendall Jackson, Herman Waguespack, Jr., Donnie D. Garrison, and Kenneth L. Quebedeaux. Outfield Variety Tests: More than just Yields

Herman Waguespack, Jr., Ray Ricaud, and Allen Arceneuux. The Effect of Shavers, Diggers, and Rolling Cultivators on the Development and Yield of Sugarcane Stubble in Louisiana

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PRESIDENT'S MESSAGE
LOUISIANA DIVISION

William R. Algu
Caldwell Sugars Co-op, Inc.

On behalf of the Louisiana Division, host of the 25th Annual Joint Meeting of the American Society of Sugar Cane Technologists, it is with great pleasure and honor that I welcome friends and guests from the Louisiana and Florida Divisions, as well as from other states and countries.

It is my sincere hope that we continue to meet and participate in this free exchange of ideas and technical knowledge. This sharing of information contributed immensely to our past success and can only strengthen and bear to fruition our goals and aspirations for the sugar industry in the future.

The Louisiana Sugar Industry completed another successful crop, one among its best, with a record sugar production of 1,018,000 tons, on January 1, 1995. The first mill started to grind cane on September 28, 1994, signaling the beginning of the grinding season. The last mill finished grinding on January 1, 1995, marking the end of another season. We had 500,000 acres of land in cultivation, 380,000 acres planted to cane, 30,000 acres used for seed, and 350,000 acres harvested for sugar.

Some 9,651,715 gross tons of cane were harvested, and 1,018,000 tons raw-value sugar were produced. The sugar recovered was 10.55 percent cane, or 211 pounds per ton of cane, and 5,820 pounds of sugar per acre with a cane yield of 27.6 tons per acre. Also, 51,500,000 gallons @ 80.00 Brix of molasses were produced.

There were 750 growers, with 667 acres of an average farm in 22 Parishes growing sugarcane, with 20 sugar mills in operation. The crop value was $448,000,000 with a total economic impact of $1,720,000,000.

The Louisiana sugarcane industry, currently celebrating its bicentennial of continuous production of sugar, has long depended upon research for its existence. Over time, these research efforts have created an integrated program with a strong cooperative effort among federal, state, and industry scientists. Growers and processors owe a tremendous debt to the researchers at the USDA facility in Houma, at the LSU Agricultural Centers in Baton Rouge and New Iberia, at the American Sugar Cane League in Thibodaux, at the University of South Western Louisiana in Lafayette, at Nicholls State University in New Orleans, at the Sugar Processing Research Institute in New Orleans, and to the numerous other scientists who do work for the Louisiana industry.

Number one in the mind of the Louisiana sugar industry is the development of new varieties. High yields of cane and sugar, early maturity, harvestability, stubbling ability, resistance to numerous pests, and cold tolerance, are among the characteristics that researchers strive for. The combination of good varieties, good growing and harvesting conditions, efficient production practices, and advances in raw sugar processing have allowed the Louisiana sugarcane industry to finally achieve an annual production level of over 1,000,000 tons of sugar. What an outstanding tribute to the scientists and industry members who have developed the varieties and technologies that have allowed the growers and processors to reach this achievement.

Research on raw sugar processing continues in an effort to maximize sugar recovery and reduce costs. Achieving high air and water standards while complying with solid waste regulations continues to involve research.

Many other research activities are conducted for the benefit of the Louisiana sugar industry. Crop production practices that maximize mechanical and chemical inputs, while maximizing economic efficiency, are active research projects. Integrated pest management systems and biological control measures for cane pests, have been developed and constantly improved upon through research. They are actively employed throughout the industry in an effort to minimize the impact of production on the environment. The protection of Louisiana's numerous natural resources is extremely important to the growers and processors of this industry. The development and utilization of Best Management Practices (BMP) have incorporated sound production and processing practices that demonstrate the industry's environmental consciousness.

The Louisiana sugarcane industry continues to be active in mechanization research. Mechanical planters are constantly being improved to reduce seed-cane usage and labor costs. Research to evaluate harvesting systems is on-going in an effort to improve the efficiency and overall costs of harvest operation.

The Louisiana industry continues to invest a small but significant percentage of its research dollars in high-risk, long-term projects. Some of this work involves alternate products which could be produced from sugarcane. Other research dollars have been spent in the area of molecular biology. Sugarcane genetics is very complicated and therefore very expensive.

The industry, working through the American Sugar Cane League, was instrumental in forming the International Consortium on Sugarcane Biotechnology. This group has numerous international members who pool their resources to fund various research projects. Significant progress has been made in mapping sugarcane chromosomes. A genetically altered sugarcane plant has now been developed through this organization which provides us with a herbicide resistant sugarcane plant. It is hoped that these results will assist the conventional variety programs in providing the tools that can allow us to remain efficient in the global community in which we now compete.

On the national level, the cane sector of the sugar industry has been relatively solid in regard to the issues involved in the negotiations of the sugar program for insertion in the upcoming Farm Bill (Food Security Act). The Louisiana industry views the upcoming Farm Bill, and more importantly the sugar program, as one of the toughest political battles that the industry will face to date.

This year, in light of the opposition from commercial sugar users and others, the Louisiana sugar industry opted to introduce legislation in the Louisiana legislature that would unquestionably irritate. But we have failed to get the attention of those entities in Louisiana whose parent companies have been opposing our industry's effort to renew its support program. The commercial users continue to tell the Congress that we are a protected industry. Premised on the fact that everyone who lives in a glass house cannot afford to cast too many stones, several pieces of legislation have been introduced in an effort to eliminate some of their protections.

Territories for franchisees as its present federal law for cold-drink bottlers and others that would fight the renewal of the sugar program. For a group that feels that we and not they are protected, it has really brought all of the "roaches out of the cracks" in opposition.

The second issue deals with the labeling of packaging that contains sweeteners. The law provides that those packages can display wording that infers that sugar and/or HFCS might be contained in the contents rather than specifying whether it is sugar or it is HFCS. The legislation introduced in the state legislature provides that the packages manufactured for sale in Louisiana shall have the actual sweetener listed and not the "and/or" language. This also seems to have struck an exposed nerve. It is hard to believe that these commercial users would not want the consuming public to know exactly what is in the package.

The objective of the proposed legislation is to help bring attention to people within our state whose parent companies are meddling in our business that no sector of the business community is operating totally without some protections provided by the government. It is hoped that these entities and their officers/owners will see fit to inject themselves into the sugar program debate on our behalf and possibly persuade some of the opponents of our program to mind their own business.

We in the Louisiana industry are determined to pursue these two items with vigor until we obtain the support in our state of those who can persuade Coca Cola, Kraft Foods, etc., that they stay out of our business. The Louisiana industry will pursue these and other pieces of legislation until such time as our message is received, or until we are successful in accomplishing our mission.

There is one other piece of legislation that will be introduced in next year's fiscal legislative session. That is to reimpose an excise tax on cold drinks within the state of Louisiana. There was previously such a tax, and the bottlers in Louisiana saw fit to convince the Louisiana legislature that a major Coca Cola bottling plant for its location. Two years later, there is still no Coca Cola bottling facility, nor have the bottlers passed on any of the savings associated with the removal of the tax. This will be pursued next year unless, as mentioned before, the bottlers and others intervene on our behalf during the current Farm Bill debate.

PRESIDENT'S MESSAGE
FLORIDA DIVISION

Michael S. Irey
United States Sugar Corporation

On behalf of the Florida Division of the American Society of Sugar Cane Technologists, I would like to express my sincere appreciation to the Louisiana Division for hosting the Twenty-Fifth Annual Joint Meeting of the Society in Fort Walton Beach, Florida. For many of us, it is a time to renew friendships. For others, it is a time for new friendships to begin. Most of all, however, it is a time to exchange information, research, and our tricks of the trade in both formal and informal settings.

I feel particularly proud today to be representing a group of men and women who have devoted a large part of their lives to contributing to and advancing one of the most noble professions in the United States today - American farming. More specifically, I am speaking of the sugar cane industry, a group of people who start work in the morning before the sun comes up and stop work somewhere around dark-thirty, six to seven days a week, nearly six months a year during the season. During the "off" season, the work load tapers off to only ten hour days, five to six days a week. No matter what else is said about the sugar industry by the news media, no one can say that we do not put in a hard and honest day's work in the fields and factories as we bring in our crops.

On behalf of the men and women of the Florida Division, it is my pleasure to report to you the results from the recently completed crop. The 1994-95 crop began on October 17 and ended 167 days later on April 2. Florida was blessed with a good growing season and a mild but extremely wet winter. Preliminary figures from the seven mills show that 1,725,403 short tons of sugar (raw value) and 94,247,021 gallons of 79.5° brix molasses were produced from 15,587,276 tons of sugar cane harvested from approximately 425,000 acres. Florida's production will account for approximately 50% of all the sugar produced from sugar cane and 21% of all sugar produced in the United States.

Approximately 92% of the 1994-95 crop was cut by mechanical harvesters. As you know, historically, the general practice of the Florida industry was to cut sugar cane by hand. As recently as the 1990-91 crop, nearly 60% of the crop was still harvested by hand. The remarkably smooth transition to almost total mechanical harvesting in such a short period of time is a credit to the entire industry. This is due in no small part to the ingenuity of our engineers in the mills and agricultural equipment shops, the dedication of our field foremen and mechanics, the determination of our management, the abilities of our researchers, and the improvements to the mechanical harvesters continually being incorporated into the machines by their manufacturers.

Looking back at the last few years, the Florida sugar industry has met with several other extraordinary challenges. For example, three new insect pests and two new diseases have been found in the Florida industry within the last five years. We continue to be attacked in both the local and national news media by "eco-zealots," well-meaning but misinformed citizens, and politicians with urban agendas. We also continue to face ever-increasing scrutiny and regulations pertaining to environmental issues on our farms.

In response to these challenges, our researchers and industry leaders have worked hard and made significant contributions to make the sugar industry an environmentally sound component of the south Florida ecosystem. Our agronomists, soil scientists, and farm managers have developed innovative procedures or "best management practices" to minimize phosphorus discharge from our fields. Our entomologists have developed programs to control insect pests using integrated programs that rely primarily on non-chemical strategies such as biological control. One company is actually raising biological control agents and releasing them to the field instead of using chemicals to control the sugar cane borer. Our geneticists continue to develop high yielding, disease-resistant varieties while taking on the new challenge of selecting varieties that are suitable for and tolerate mechanical harvesting. On the factory side, our mills continue to implement changes that increase sucrose extraction efficiency and better utilize the byproducts of sugar manufacturing. An excellent example of this are the cogeneration facilities currently in place and under construction throughout the industry.

Thanks to the efforts by leaders of private companies and local communities within the Everglades Agricultural Area, along with the efforts of individuals working in the sugar industry, significant progress was made over the last year in educating consumers, environmentalists, politicians, and the press who unfairly criticize our industry. As a result of the efforts of a great many people, the historic Everglades Forever Act was signed into law by Florida Governor Lawton Chiles in May, 1994. Fully supported by the Department of the Interior, the Justice Department, the Florida Department of Environmental Protection, and the South Florida Water Management District, this act is the most comprehensive environmental legislation ever passed. It requires sugar farmers to meet water quality standards higher than those of rainfall, pay more than $320 million dollars in restoration costs, and set aside 60 square miles of productive farmland for filter marshes. As radical environmentalists continue to complain, Florida's sugar industry has already started the restoration efforts.

Just as Florida receives the lion's share of environmental attention, so has the American sugar industry received more than its fair share of the debate surrounding the 1995 Farm Bill. The revisions and proposals soon to be forthcoming will affect us all. With the commitment of the federal government to reduce the federal budget, it is likely that agriculture will be a target in the budget reduction process. This challenges the sugar industry to once again convince Congress that the current American sugar policy is sound and worthy of renewal. A program that employs 420,000 people nationwide, operates at no cost to the federal treasury, and protects American farmers and consumers from the whims of the world sugar market is a program that ought to be emulated, not emasculated.

With slogans of "corporate welfare" and "free trade," our opponents seek to turn public and Congressional opinion against us. Our answer must be a united front of support for the program that protects American sugar farmers from heavily subsidized foreign growers. Dismantling the U.S. sugar policy will not magically create free trade. Truly free trade will come only after Gatt-type discussions convince the Europeans and others that we must multilaterally disarm all sugar programs.

It is important that the American Society of Sugar Cane Technologists and all its members work together -- not only to renew the U.S. Sugar Program, but also to find ways of improving yield, increasing mill efficiency, and developing the technology to ensure that the American sugar industry remains competitive in any market situation. I am confident that together we can and we will. Whatever the challenges of the future, our industry will deal with them the same way we have done in the past, that is with honesty, integrity, good work ethics, dedication, and commitment. Using these time honored attributes, we will continue to move forward, and you, fellow members of our Society, will be vital contributors to this process and will be listed among those who have fought the good fight, finished the race, and kept the faith.

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ARTICLES

AGRICULTURAL
SECTION

SUGARCANE YIELD AS AFFECTED BY ANNUAL GLYPHOSATE RIPENER TREATMENTS

R. W. Millhollon and B. L. Legendre
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U.S. Department of Agriculture
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ABSTRACT

The sugarcane ripener glyphosate (POLADO L) is labelled for use only in ratoon crops in Louisiana, Florida, and Texas. This study determined the effect of annual glyphosate applications on growth and yield of several cultivars (*Saccharum* interspecific hybrids) during a 3-yr crop cycle in Louisiana, beginning in the plant-cane crop and continuing into the first- and second-ratoon crops. Annual applications of glyphosate at 0.23 kg acid equivalent (ae)/ha and a treatment-harvest interval (THI) of 27 to 42 days consistently increased the sucrose concentration of juice and theoretical recoverable sugar per kg cane (TRS) in the plant cane and ratoon crops of cultivars, as compared to untreated controls. However, whereas mean annual TRS was increased 14% and 15% at a THI of 42 and 30 days, respectively, mean annual sugar yield, the product of TRS and cane yield, was increased only 6% and 7%, respectively, because of the generally adverse effect of treatments on cane yield. Glyphosate treatments decreased cane yield by slowing cane growth immediately after treatment, thus reducing stalk weight, and by occasionally retarding or reducing regrowth (ratooning) of some cultivars in the following crop (first-ratoon crop in one experiment and second-ratoon crop in another). This study indicates that annual glyphosate ripener treatments will usually increase mean annual sugar yield, but the magnitude of the increase will depend on cultivar tolerance to the treatments. Cultivar CP 70-321 appeared to have adequate tolerance to annual treatments, whereas CP 65-357 was too sensitive.

INTRODUCTION

In Louisiana, a sugarcane crop cycle usually consists of a fall-planted crop (plant-cane), which grows very little during winter and is harvested about 1 year after planting, and two ratoon crops. The region has a 7- to 9-month growing season that extends from early spring to late November or until harvest during the period from early October to late December. Consequently, sugarcane is relatively immature at the beginning of harvest and sucrose levels are usually low, generally increasing as the harvest season advances, depending on cultivar. Sucrose levels in juice and sugar yield are affected greatly by cultivar and by the growing season before and during harvest. A combination of high incident light, cool night temperatures, and drying soil prior to and during the harvest period retards vegetative growth and promotes sucrose accumulation (natural ripening) (Legendre, 1975).

Artificial ripening of sugarcane has been made possible by the development of plant growth regulators that hasten sugarcane maturation and increase sugar yield (Nickell, 1984). Glyphosate [isopropylamine salt of N-(phosphonomethyl)glycine], one of the most effective chemical ripeners, apparently influences the way dry matter is partitioned, increasing the ratio of sucrose to fiber (Osgood et al, 1981). In Louisiana, the effectiveness of glyphosate for ripening sugarcane is strongly dependent upon cultivar, treatment-harvest interval (THI), and growing season (Legendre and Finger, 1987; Martin et al, 1981). Certain Louisiana cultivars, such as CP 65-357, respond very positively to glyphosate at a relatively short THI whereas others are less responsive or require a longer THI. In one study with CP 65-357, consisting of 16 tests in 1979, glyphosate at 0.3 kg ae/ha and a THI of 22 days increased both commercially recoverable sugar/ton cane and sugar yield by 7.4% (Martin, et al, 1981). However, the response of cultivars to glyphosate varies with the growing season as shown by another study in which CP 65-357 at a 42-day THI had a 31% increase in sugar yield in one year and an 11% increase in another, with no significant decrease in stalk wt during either year (Legendre and Finger, 1987). In the latter study, glyphosate generally reduced stalk wt of all cultivars when the THI exceeded 42 days.

The glyphosate label for sucrose enhancement in Louisiana, Florida, and Texas stipulates use only in ratoon crops, a rate range of 0.14 to 0.33 kg ae/ha, and a THI of 21 to 35 days. Glyphosate is not labelled for plant-cane crops in these states because of possible phytotoxicity to crown buds which could adversely affect regrowth (ratooning), thus reducing stands and yield in the ratoon crops. Glyphosate is labelled for both plant-cane and ratoon crops in Hawaii where each crop is grown for 2 years before harvest. Slow stand development in spring is commonly observed in glyphosate-treated sugarcane in Louisiana, but major reductions in regrowth, stalk population, and yield have not been reported except at high rates (>0.45 kg ae/ha) and a THI greater than 42 days (Legendre, et al, 1980). However, in Florida more extensive stand and yield reductions have been reported (Rice, et al, 1984; Watson and DeStefano, 1986). The purpose of this study was to determine the effect of annual applications of glyphosate on growth and yield of several sugarcane cultivars during a crop cycle in Louisiana, beginning in the plant-cane crop.

MATERIALS AND METHODS

Two glyphosate treatment by cultivar factorial experiments were conducted at the Sugarcane Research Unit Farm near Houma, Louisiana from 1989 to 1991 (experiment 1) and 1993 to 1995 (experiment 2) on silt loam soils (fine-silty, mixed, nonacid, thermic Typic Fluvaquent, 1.6% organic matter, and pH of 6.5). Sugarcane cultivars in experiment 1 were CP 65-357, CP 70-321, and CP 74-383 and in experiment 2, CP 65-357, CP 70-321, LCP 82-89, and LHo 83-153. Experiment 1 was a 5 by 3 complete factorial arranged in a randomized complete block with four replications and a plot size of three rows (1.8 m spacing) by 6.1 m. Experiment 2 was a 2 by 4 factorial arranged in a split plot design with cultivars as whole plots and glyphosate treatments as sub plots (one row by 9.1 m) arranged in a randomized complete block design with five replications. A 1.25-m cane buffer separated plots within the same row of cane, and a buffer row of cane separated adjacent plots in adjoining rows. An untreated control was included as one of the glyphosate treatments in both experiments.

Glyphosate (POLADO L[1]), mixed with water containing a 0.25% (v/v) nonionic surfactant and 0.03% (v/v) drift-control agent (NALCO-TROL[1]), was applied at 0.23 kg ae/ha with a back-pack, CO_2-pressurized sprayer and hand-held boom. The sprayer was calibrated to deliver a broadcast volume of 187 L/ha, but sprays were applied in a 122-cm band over sugarcane foliage, wetting most of the leaves. In Experiment 1, glyphosate was applied at a 27- or 42-day THI during the 3-yr crop cycle, either annually in the plant-cane, first-ratoon, and second-ratoon crops, or only in the ratoon crops. Harvest dates were November 14, 1989 (plant-cane), November 7, 1990 (first-ratoon), and October 23, 1991 (second-ratoon). Glyphosate applied in the plant-cane crop at the 27-day THI received rainfall of 1.9 cm, about 3 hours after treatment which probably washed some of the chemical from plants. Also, a severe winter freeze (minimum temperatures of -12°C air and +1°C soil at 10-cm depth) occurred in December, 1989,

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[1] A proprietary name is necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

30 days after harvest of the plant-cane crop (58 and 76 days after glyphosate was applied at the 42-day and 27-day THI, respectively). In Experiment 2, glyphosate was applied annually at a 30-day THI in the plant-cane, first- and second-ratoon crops; harvest dates were November 18, 1993 (plant-cane), October 19, 1994 (first-ratoon) and October 17, 1995 (second-ratoon).

Plots were maintained weed-free by annual preemergence applications of metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one] at 1.0 kg active ingredient (ai)/ha and by annual spring postemergence applications of a mixture of amine 2,4-D at 1.0 kg ae/ha and dicamba (3,6-dichloro-2-methoxybenzoic acid) at 0.5 kg ae/ha. Sugarcane was fertilized annually with N, P, and K as recommended by the Louisiana Agricultural Extension Service for good growth of sugarcane, and sugarcane borer (*Diatraea saccharalis*) was controlled as needed by insecticides.

Plots were harvested with a whole-stalk harvester that cut stalks at ground level and removed leafy tops at a point near the apical meristem (bud). Stalks were then burned to remove dried leafy trash and weighed; stalk wt was determined from total wt of stalks/plot divided by their number, based on stalk count in August or September prior to harvest. A 15-stalk sample from each harvested plot was crushed once in a three-roller sample mill (about 50% juice extraction), and the juice analyzed for Brix by refractometer, apparent sucrose by polarimetry, and purity as the ratio of apparent sucrose to Brix using standard methods (Chen and Chou, 1993). The yield of theoretical recoverable sugar per kg cane (TRS) was calculated by methods previously described (Legendre and Henderson, 1972) and used to calculate yield of sugar/ha (cane/ha x TRS). To determine fiber, a 5-stalk sample was passed through a prebreaker to finely shred the stalks; a 1 kg sample from the prebreaker was pressed for 2 minutes at 3000 psi to separate the cane juice and residue (bagasse); and fiber percent cane calculated by methods previously described (Legendre, 1992). Data were analyzed according to standard analysis of variance methods and least significant difference (LSD, P=0.05) was used for mean separation.

RESULTS AND DISCUSSION

In the plant-cane crop of experiment 1, glyphosate at the 27- and 42-day THI increased sucrose and purity which led to a 4 and 12% increase in TRS, respectively, as compared to the untreated control (Table 1). The activity of glyphosate at the 27-day THI may have been reduced by a rain about 3 hours after application since the label states that rain 6 hours after treatment can reduce effectiveness. Sugar yield, the product of TRS and cane yield, was increased 11% over the untreated control at the 42-day THI, but was not significantly different from control at the 27-day THI. The glyphosate treatments did not adversely affect stalk population, stalk weight, or cane yield.

In the first-ratoon crop, TRS again increased as THI increased, but the number of glyphosate treatments during the 2-year span — two applications (plant-cane and first-ratoon crops) versus one application (first-ratoon crop) — had very little affect on TRS (Table 1). The increase in TRS as an average of the one- and two-application treatments was 4 and 9% for the 27- and 42-day THI, respectively. The large increase in TRS at the 42-day THI resulted in an increase in sugar yield when glyphosate was applied only in the first-ratoon crop, but sugar yield was not increased when glyphosate was applied both in the plant-cane and first-ratoon crops because of a cultivar by treatment interaction. The interaction was caused by the differential effect of glyphosate treatment in the plant-cane crop on regrowth (ratooning) of the three cultivars (Tables 1 and 2). Shoot and stalk populations of CP 65-357 in the first-ratoon crop were reduced by 32 and 18%, respectively, as compared to the untreated control, whereas populations of CP 70-321 or CP 74-383 were not affected (Table 2). The reduction in stalk population of

CP 65-357 also led to a 23% reduction in cane yield, although the glyphosate application in the first-ratoon crop may have contributed to the reduction. Cane yields for cultivars CP 70-321 and CP 74-383, were lower, but not significantly different from control. The stand reduction in CP 65-357 probably was the result of a combination of glyphosate treatment and a severe freeze that occurred 30 days after harvest of the plant-cane crop since CP 65-357 is known to be relatively sensitive to both glyphosate and such freezes. However, the relatively high cane yield in untreated control plots for all three cultivars (Table 2) indicate that the freeze caused very little direct injury at this location whereas large yield losses from the freeze in both CP 65-357 and CP 70-321 were observed at several other locations in Louisiana.

By the second-ratoon crop, CP 65-357 had recovered considerably from stand reductions caused by the glyphosate treatment and the freeze as shown by the lack of a significant cultivar by treatment interaction for mean stalk population and cane yield (Table 1). As observed in the first-ratoon crop, glyphosate increased TRS more at the 42-day THI (23%) than at the 27-day THI (12%), and the number of glyphosate applications during the crop cycle — three beginning in the plant-cane crop versus two in the ratoon crops — had very little affect on TRS. At the 27-day THI, sugar yields, although higher, were not significantly different from control whether applied annually or only in the ratoon crops, but at the 42-day THI sugar yields were 11% higher than the control when glyphosate was applied annually and 15% higher when applied only in the ratoon crops.

When mean annual yields and yield components for the 3-year crop cycle are considered, glyphosate applied annually at the 42-day THI increased TRS 14% but increased sugar yield only 6%, because of an 8% reduction in cane yield (Table 1). Glyphosate applied only in the ratoon crops at the 42-day THI produced sugar yield similar to that for the annual treatment but as the result of different yield characteristics — less increase in TRS (10%) but higher cane yield. When mean annual yields for the 42-day THI were calculated using CP 70-321 and CP 74-383, excluding CP 65-357, the increase in sugar yield was 10% when applied annually and 7% when applied only in the ratoon crops (data not presented). Glyphosate at the 27-THI increased TRS 7% when applied annually and 5% when applied only in the ratoon crops, but did not significantly increase sugar yield because of a slight, although nonsignificant, reduction in cane yield. Glyphosate treatments as a group reduced stalk weight and as a result caused some reduction in cane yield; therefore, large increases in TRS were required to significantly increase sugar yields over that of the untreated controls.

In Experiment 2, glyphosate treatments consistently increased sucrose, purity, and TRS in each crop, with a mean annual increase in TRS of 15% (Table 3). However, because of the generally lower stalk weight and cane yield that resulted from glyphosate treatments in each crop, the increase in mean annual sugar yield was only 7%. If glyphosate had been applied only in the ratoon crops, the estimated increase in mean annual sugar yield would have been 5% (calculated by averaging the yield of untreated cane in the plant-cane crop with the yields of treated cane in the first- and second-ratoon crops). The greatest decrease in cane yield occurred in the second-ratoon crop but was primarily caused by the glyphosate treatment in the first-ratoon crop which adversely affected ratooning (shoot population in June) of all cultivars as a group (Table 4). The shoot population of CP 65-357 and LCP 82-89 appeared to be reduced more than that of CP 70-321 and LHo 83-153, but the cultivar by treatment interaction was not significant. The effect of this treatment on ratooning was visibly evident in early spring because of both reduction in shoot number and height, as compared to untreated controls. The effect was still evident in late summer, before the glyphosate application in the second-ratoon crop, in terms of reduced stalk population for cultivars as a group (Tables 3 and 4) and reduced height (data not presented). The combined effect of the glyphosate treatments in the first- and second-ratoon crops affected stalk population and cane yield of cultivars differentially as shown by a significant cultivar by treatment interaction (Table 4). Reductions in cane yield were greatest for CP 65-357 (16%), least for CP 70-321 (no significant reduction), and intermediate for LCP 82-89 (11%) and LHo 83-153 (8%). No significant cultivar by treatment interaction was found for sugar yield, but the decrease in cane yield for CP 65-357 and LCP 82-89 obviously prevented higher sugar yield for these cultivars (Table 4).

In both experiments 1 and 2 glyphosate ripener treatments did not affect the fiber content of stalks as compared to the untreated controls (data not presented).

This study indicated that annual glyphosate ripener treatments during a crop cycle can consistently increase sucrose, purity and TRS and have a positive effect on mean annual sugar yield of most cultivars. However, the study also indicated that such treatments can lower cane yield because of possible immediate and/or delayed phytotoxicity to cane, thus limiting potential increases in sugar yield. The immediate effect of glyphosate was to slow cane growth soon after treatment, thus frequently causing some reduction in stalk weight and subsequently cane yield, although the yield loss was not always significantly different from control. The delayed effect was to occasionally retard regrowth of some cultivars in the following ratoon crop to the extent that stalk population and cane yield were also reduced. In annual ripener treatments, the possible adverse effect of glyphosate on ratooning is of particular concern because such phytotoxicity early in the crop cycle could reduce yields in the following ratoon crops; therefore, the choice of cultivar(s) for such treatments is an important consideration. Ideally, the cultivar chosen for annual treatments should have several desirable attributes: consistent ripening in response to treatment, good tolerance to the treatments, particularly in terms of ratooning, and relatively good tolerance to after-harvest freezes since the combined effect of a severe freeze and glyphosate treatment could cause greater stand reductions than either stress alone. Cultivar CP 70-321 showed good tolerance to glyphosate treatments in the two experiments of this study and appears suitable for annual treatments whereas cultivar CP 65-357 was much more sensitive to glyphosate and probably is best suited for treatment only in the last ratoon crop. More data will be needed to determine the suitability of the other cultivars for annual treatments. However, if glyphosate is to be applied annually in Louisiana for ripening of sugarcane, the label will require modification to permit use in plant-cane as well as ratoon crops.

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Table 1. Effect of annual glyphosate ripener treatments on juice and yield characteristics in a 3-yr crop of sugarcane (mean of cultivars CP 65-357, CP 70-321, and CP 74-383) (experiment 1)[a].

Treatment-harvest interval by crop (days)			Juice		Harvestable stalks			Yield	
Plant cane	Ratoon								
	1st	2nd	Sucrose	Purity	Population	Wt.	TRS	Cane	Sugar
			%	%	no./ha x 10^3	g x 10	g/kg	kg/ha x 10^3	
Plant-cane:									
UNT	–	–	16.9	89.1	70	128	126	90	11.3
27	–	–	17.7	89.5	70	126	131	89	11.6
42	–	–	18.7	91.1	71	126	141	90	12.6
LSD (0.05)			0.4	1.0	NS	NS	3	NS	0.6
1st ratoon:									
UNT	UNT	–	16.5	88.3	73	127	122	92	11.2
UNT	27	–	17.1	88.6	75	120	126	90	11.3
27	27	–	17.2	88.9	74	121	128	89	11.3
UNT	42	–	17.8	90.0	74	121	132	89	11.8
42	42	–	17.9	90.2	70	117	134	81	10.8
LSD (0.05)			0.4	0.8	—[b]	NS	3	—[b]	0.5
2nd ratoon:									
UNT	UNT	UNT	13.8	83.6	72	104	99	75	7.4
UNT	27	27	15.3	85.8	75	94	112	70	7.8
27	27	27	15.2	86.1	74	98	111	72	8.0
UNT	42	42	16.5	87.7	74	95	122	70	8.6
42	42	42	16.5	88.3	73	93	122	68	8.3
LSD (0.05)			0.6	1.6	NS	NS	5	NS	0.8
Mean - 3-yr crop:									
UNT	UNT	UNT	15.7	87.0	72	120	116	86	10.0
UNT	27	27	16.5	87.7	73	113	121	84	10.2
27	27	27	16.7	88.2	73	115	123	83	10.3
UNT	42	42	17.1	88.7	74	114	127	83	10.6
42	42	42	17.7	89.8	71	112	132	79	10.6
LSD (0.05)			0.3	0.6	NS	5	3	4	0.5

[a] Abbreviations: UNT = untreated; TRS = theoretical recoverable sugar in stalks.

[b] A significant treatment by cultivar interaction occurred for stalk population and cane yield, thus LSD values are not stated.

Table 2. Differential effect of glyphosate ripener treatments in the plant-cane crop on population and yield of cultivars in the first-ratoon crop (experiment 1).

Treatment-harvest interval by crop (days)		Population and yield in first-ratoon crop by cultivar			
Plant cane	First- ratoon [a]	CP 65-357	CP 70-321	CP 74-383	Mean
		Shoots in June (no./ha x 10^3)			
UNT [b]	—	85	81	78	-
27	—	73	82	79	-
42	—	58	88	74	-
LSD (0.05) for treatment means within a cultivar			15		
		Stalks in August (no./ha x 10^3)			
UNT	—	79	72	72	-
27	—	77	72	71	-
42	—	65	71	72	-
LSD (0.05) for treatment means within a cultivar			7		
		Cane yield in November (kg/ha x 10^3)			
UNT	UNT	98	90	88	-
UNT	27	96	86	88	-
27	27	90	86	91	-
UNT	42	94	89	85	-
42	42	75	84	84	-
LSD (0.05) for treatment means within a cultivar			8		
		Sugar yield in November (kg/ha x 10^3) [c]			
UNT	UNT	11.9	11.5	10.1	11.2
UNT	27	11.8	11.3	10.9	11.3
27	27	11.2	11.5	11.3	11.3
UNT	42	12.4	12.1	10.9	11.8
42	42	10.2	11.6	10.8	10.8
LSD (0.05) for treatment means as an average of all cultivars		--	--	--	0.5

[a] Dashes indicate that treatments in the first-ratoon crop had not been applied when data were obtained.

[b] Untreated.

[c] The cultivar by treatment interaction for sugar yield was not significant at *P*=0.05.

Table 3. Effect of annual glyphosate ripener treatments (30-day treatment-harvest interval) on juice and yield characteristics in a 3-yr crop cycle (means of sugarcane cultivars CP 65-357, CP 70-321, LCP 82-89, and LHo 83-153) (experiment 2)[a].

Glyphosate treatment by crop			Juice		Harvestable stalks				Yield	
Plant cane	Ratoon									
	1st	2nd	Sucrose	Purity	Population	Ht.[b]	Wt.	TRS	Cane	Sugar
			%	%	no./ha x 10^3	cm	g x 10	g/kg	kg/ha x 10^3	
Plant-cane:										
UNT	—	—	14.7	85.8	76	297	102	107	78	8.3
TRT	—	—	15.7	87.0	77	287	100	115	77	8.8
LSD (0.05)			0.5	1.1	NS	6	NS	4	NS	0.4
1st ratoon:										
UNT	UNT	—	14.7	84.9	80	279	102	106	81	8.5
TRT	TRT	—	16.5	87.3	82	271	98	121	79	9.5
LSD (0.05)			0.3	0.7	NS	3	2	3	NS	0.4
2nd ratoon:										
UNT	UNT	UNT	15.1	84.3	95	—	86	109	82	8.9
TRT	TRT	TRT	17.1	86.5	91	—	82	125	74	9.2
LSD (0.05)			0.3	0.8	-[c]	—	2	3	-[c]	NS
Mean - 3yr crop:										
UNT	UNT	UNT	14.8	85.0	84	—	97	107	80	8.6
TRT	TRT	TRT	16.4	87.0	83	—	93	120	77	9.2
LSD (0.05)			0.3	0.7	NS	—	2	2	2	0.3

[a] Abbreviations: UNT = untreated; TRT = treated; TRS = theoretical recoverable sugar in stalks.

[b] A dash indicates no data was obtained.

[c] A significant cultivar by treatment interaction occurred for stalk population and cane yield, thus LSD values are not stated.

Table 4. Differential effect of glyphosate ripener treatments in the first-ratoon crop on population and yield of cultivars in the second-ratoon crop (experiment 2).

Crop treated with glyphosate [a]			Population and yield in second-ratoon crop by cultivar				
Plant cane	Ratoon						
	1st	2nd [b]	CP 65-357	CP 70-321	LCP 82-89	LHo 83-153	Mean
			Shoots in June (no./ha x 10^3) [c]				
UNT	UNT	–	115	116	122	138	123
TRT	TRT	–	100	111	108	134	113
LSD (0.05) for treatment means over all cultivars			--	--	--	--	5
			Stalks in August (no./ha x 10^3)				
UNT	UNT	–	97	85	97	102	--
TRT	TRT	–	85	84	91	102	--
LSD (0.05) for treatment means within a cultivar			6				
			Cane yield in November (kg/ha x 10^3)				
UNT	UNT	UNT	82	80	81	84	--
TRT	TRT	TRT	69	77	72	77	--
LSD (0.05) for treatment means within a cultivar			5				
			Sugar yield in November (kg/ha x 10^3) [c]				
UNT	UNT	UNT	8.9	9.5	8.8	8.3	8.9
TRT	TRT	TRT	9.0	10.1	9.0	8.7	9.2
LSD (0.05) for treatment means as an average of all cultivars			--	--	--	--	NS

[a] Abbreviations: UNT = untreated; TRT = treated.

[b] Dashes indicate that treatments in the second-ratoon crop had not been applied when data was obtained.

[c] Cultivar x treatment interaction for shoot population and sugar yield were not significant at P=0.05.

SUBSURFACE DRAINING JEANERETTE SOIL TO INCREASE CANE AND SUGAR YIELDS

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ABSTRACT

An experiment was conducted in Iberia Parish, Louisiana during 1980-1990 to determine soil and crop response to subsurface drainage. Three subsurface drain spacings, 45-ft, 90-ft, and 135-ft, were tested on Jeanerette silty clay loam soil. The soil responded favorably to subsurface drainage. In the subsurface drained areas, the average SEW_{12} values, which is a measure of the magnitude and duration of the water table within 12 inches of the soil surface, were from 63 to 89 percent less than the average SEW_{12} values from the non-drained area. Cane and sugar yield also improved with subsurface drainage. Average cane yields from the subsurface drained treatments were from 2.0 T/A to 4.2 T/A greater (up to 16 percent greater) than yield from the non-drained check and the differences were significant. Average sugar yields from the subsurface drained treatments were from 711 lbs/A to 937 lbs/A greater (up to 21 percent greater) than yield from the non-drained area and the differences were highly significant. The recommended drain spacing for Jeanerette silty clay loam soil for increasing cane and sugar yields is 135 feet. Using 1994 drain installation costs and sugar prices, installing subsurface drainage systems with drains spaced 135-ft was justified because the value of the increase in sugar yields exceeded the cost of installing subsurface drainage at that spacing.

INTRODUCTION

Relatively low and variable crop yields in Louisiana are attributed to weather more than any other factor. Although little can be done about the weather, there are several farming practices that deal with the consequences of weather and will certainly aid crop production. For example,the practices of irrigating during droughts, surface draining to remove excess water from the soil surface, subsurface draining to remove excess water from the soil profile, selecting varieties for proper maturity, selecting varieties for disease control, and selecting varieties for crop tolerance to cold temperatures all tend to reduce the adverse effects of weather on crop production.

During the past 20 years, sugarcane growers in Louisiana have placed much emphasis on surface drainage and variety selection for disease resistance and cold tolerance. Little effort has been made to improve soil profile drainage or to irrigate. An analysis of weather variables in the sugar cane growing area of Louisiana indicates that the average annual evapotranspiration demand is about 42 inches/year, yet average annual rainfall is 57 inches and greater (Thornthwaite 1957, Carter 1977a, US Dept. of Commerce 1992). Monthly evapotranspiration varies from less than one inch in January, February, and December to approximately seven inches in June, July, and August (Carter 1977a). During most years, rainfall in June, July, and August is not sufficient to meet the evapotranspiration demand, indicating the need for irrigation. On the other hand, rainfall during the remaining months of the year usually exceeds evapotranspiration. This excess water (rainfall volume less evapotranspiration volume) will either pond on the soil surface, runoff, or infiltrate into the soil and cause the water table to rise. The consequences of a high water table are inhibited crop growth, reduced stand longevity, reduced crop yield, and interference with timely field operations.

Because surface drainage of sugarcane land is reasonably good, poor soil profile drainage appears to be a factor that could be causing or contributing to the leveling off of average annual sugarcane yields. The average sugarcane yield in Louisiana has been relatively constant at approximately 24 tons/A for the past 10 years (USDA 1985-1993).

To determine the soil and crop response to subsurface drainage, several experiments were conducted beginning in the mid-1960's. The first experiments were conducted on small (0.01 acre) concrete bordered plots located near Baton Rouge, LA where the water table could be precisely controlled (Carter, et al. 1970, Carter 1977b). These experiments showed that subsurface drainage increased cane and sugar yields and increased cane stubble longevity (Carter and Floyd 1973, Carter 1975). Because these experiments were conducted on very small plots on a Mhoon/Commerce silt loam with precise water table control, there was a need to conduct subsurface drainage experiments on field-size areas with field subsurface drainage systems on different soils. Field-size experiments were installed in Tensas, Iberville, St. James, St. Mary, and Iberia parishes in the late 1970's. This paper reports the results from the experiment in Iberia Parish, the objective of which was to determine soil and crop response to subsurface drainage of a Jeanerette silty clay loam planted in sugarcane.

MATERIALS AND METHODS

A Jeanerette (Typic Argiaquoll) silty clay loam site at the William Patout III farm in Iberia Parish, Louisiana was selected for this subsurface drainage experiment. Four tracts, each approximately 3.7A (800 by 200 feet) were used (Figure 1). Subsurface drains were installed on three tracts in 1978. One tract not subsurface drained was used as a check. The perforated, corrugated, polyethylene subsurface drains were four inches in diameter and were wrapped with Typar[1] filter material. The drains were installed approximately 3 ft deep with a drain-tube plow equipped with a laser grade control system. The first tract had four drains spaced 45-feet apart, the second tract had three drains spaced 90-feet apart, and the third tract had two drains spaced 135-feet apart. Drains in the three tracts were connected to two steel sumps, each approximately 4 by 4 by 10 ft deep, that were equipped with two 0.5-hp pumps each. These discharged drain effluent into a surface drainage ditch. Drain effluent was measured after February, 1981 with commercial-type water meters. Consequently, no drain outflow data were collected during the early part of this experiment.

The non-drained tract was located across a drainage ditch from the 135-ft drain spacing treatment (Figure 1). Each tract was bordered on the sides by surface drainage ditches approximately two-ft deep and on the downslope end by a surface drainage ditch approximately three-ft deep (Figure 1). The tracts were bordered on the up-slope ends by field roads. All tracts were planted to sugarcane in the fall of 1979. Conventional cultural practices were used throughout the experiment, which included planting on 12-inch high beds with rows spaced 70-in apart. Fertilizer and pesticides were applied at rates recommended by the Louisiana Cooperative Agricultural Extension Service.

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[1] Trade and company names are listed for the readers' benefit and do not imply endorsement or preferential treatment by USDA.

At harvest time, a whole-stalk mechanical harvester was used to cut, top, and place the cane stalks in either three- or four-row heaps after which the leaves remaining on the stalks were burned. Sugarcane stalks from four sites (each approximately 0.3 A in size) in each tract were transported to the factory, weighed for yield estimates, and tested for sucrose content. Sugar yield was determined from cane weight and sucrose content. Mean treatment yields were compared to determine crop response to drainage and drain spacings.

At or prior to harvest time each year, plant population estimates were determined by counting the number of harvestable stalks on 200 ft of four rows in each tract. Stalk weights were determined by dividing cane weights by stalk populations. Normally, three annual sugarcane crops are harvested from one planting in Louisiana. During this experiment, a new crop was planted three different times, in the falls of 1979, 1983, and 1988. Sugarcane cultivar NCo-310 was planted in 1979 and CP 70-321 was planted in 1983 and 1988. Three crops were harvested from the first planting, four crops from the second planting and only two crops from the third planting. Below-freezing temperatures in December 1989 severely damaged the stubble of the 1988 planting, which severely reduced 1990 crop yields. Consequently, the landowner chose to destroy the stubble and replant in the fall of 1991. Because the objectives of this experiment had been met, the project was terminated after crop harvest in 1990.

Rainfall was measured with a weighing-type rain gauge located at the site. Water table depths were measured with water stage recorders, one recorder installed in each tract. Water stage recorders were located midway between two parallel subsurface drains in the drained areas and near the middle of the tract in the check area. Each recorder was positioned over a 6-ft length of 6-in diameter PVC pipe that was inserted vertically in a 5-ft-deep hole augered into the soil; the well casing extended 12-in above the soil surface. The deepest 4-ft section of pipe was perforated so that water could readily flow through the PVC well casing. The soil surface was sloped away from the well casing to prevent surface water from entering the wells. Recorders were supported by stands positioned over the pipe which also insured that the float and counterweight remained within the PVC pipe. Recorders were installed in 1979 and remained in place throughout the experiment except for periods in November and December each year when they were removed for harvest, and all year during 1983 and 1988 when the land was fallow plowed and seedbeds were prepared for re-planting. Water table data from recorder charts were mechanically digitized and stored in computer files. These data were used to determine the number and duration of events when the water table was within 12 inches of the soil surface.

Because only two sumps were available for outlets for the three subsurface drained tracts, flow from each tract could not be measured separately. One sump collected drainage effluent from the four drain lines in the 45-ft spacing treatment and one drain line in the 90-ft drain spacing treatment. The other sump collected effluent from two drains in the 135-ft drain spacing treatment and two drain lines in the 90-ft spacing treatment. The effluent discharge from each sump was measured and the two discharge volumes were combined to provide the total drain outflow volume from the subsurface drained tracts.

A term commonly used to report effectiveness of subsurface drainage is SEW_{12}, the summation of excess water (Wesseling 1974). This term expresses the magnitude and duration of the water table within the top 12 inches of the soil surface. SEW_{12} is determined by plotting water table depth vs time, drawing a line on the graph at 12 inches below the soil surface, and then summing the daily magnitude values when the water table was closer than 12 inches to the soil surface. For example, if the water table rose to eight inches below the soil surface and remained there for three days, the excess water for this three-day period would be 3(12 - 8) = 12 inch-days. If the water table were 4 inches from the soil surface for three days, the excess water would be 3(12 - 4) = 24 inch-days. SEW_{12} , is the summation of excess water calculated during a given period, usually during a growing season. Sieben (1964), who developed the SEW concept in the Netherlands, determined that yield of cereal grains began to decline as SEW_{12} values, during the growing season, increased above 40 inch-days. Because sugarcane is a ratoon crop, SEW should be calculated for the entire year rather than for the growing season. For the calculations in this paper, the soil surface was assumed to be the average of the cane row top and·the furrow bottom elevations.

The rainfall and water table recorders were equipped with clocks that ran for several months between servicing. However, we checked the recorders and changed the charts much more frequently, usually at two- or three-week intervals. When the charts were changed, the water meter readings were recorded. Occasionally the electric power meter, which measured the power used by the sump pumps, was observed and these data were recorded. The water and electric meter data were used to determine the volume of water drained from the plots and the amount of electricity used to pump the water from the sumps into a surface drainage ditch.

The cost of installing the subsurface drainage system was estimated. The material costs, based on 1994 prices and quoted by a plastic drain tubing company representative, were $0.29/ft for 4-in perforated plastic drain tubes with filter fabric, $4.80 each for tee adapters, $0.70 each for drain tube couplers, $0.80 each for end caps, and $0.45/ft for 6-in diameter main drain tubing. The cost for a sump and pump for drainage outlet was estimated at $100/A. Because no subsurface drainage contractors are currently located in Louisiana, the drain line installation cost was estimated at $0.28/ft, based on the average cost for several drain installations in the Midwestern area of the United States.

Because of the size and nature of this experiment, it was not feasible to replicate the drain spacing treatments. However, years were used as replications (nine years of yield data) and these data were analyzed statistically for normality, interactions, differences, and trends using univariate analysis, plotting programs, and ANOVA methods available from the Experimental Statistics Department at Louisiana State University.

RESULTS AND DISCUSSION

Annual rainfall amounts varied considerably during this experiment, ranging from 42.99 inches in 1990 to 70.52 inches in 1982 (Table 1). Average annual rainfall for the period 1980-1990 was 57.20 inches, which was slightly lower than the long-term average for Iberia Parish of 59.10 inches (U. S. Dept. of Commerce 1993). Monthly rainfall varied from 0.59 inches in February 1981 to 18.82 inches in October 1984.

Rainfall raised the water table to near the soil surface on many occasions. In the non-drained tract, the water table remained near the soil surface for several days following significant rainfall while the water table in the drained tracts receded to a depth of 12 inches and more, soon after rainfall (Figures 2, 3, and 4).

The time period that the water table was within 12 inches of the soil surface averaged 3.8, 7.1, and 13.1 days in the 45-, 90-, and 135-ft drain spacing treatments, respectively (Table 1). In the non-drained check, the water table was within 12 inches of the soil surface an average of 49.4 days during the nine years that water table measurements were made (Table 1). In 1982, the water table in the non-drained tract was within 12 inches of the soil surface 70.9 days; in the subsurface drained tracts the water table was within 12 inches of the soil surface only 25.3, 7.3 and 0 days in the 135-, 90-, and 45-ft drain spacing treatments, respectively (Table 1). This measure, however, provides only one dimension, time.

SEW_{12} values reflect not only the presence of the water table within the top 12 inches of the soil but also how close it was to the soil surface. Annual SEW_{12} values varied considerably, but, like the time period, they were less for the 45-ft spaced drains and increased as drain spacing increased in all cases. The SEW_{12} values were greatest in the non-drained tract (Table 1). Because SEW is more comprehensive in quantifying the water table's effect on crop growth, SEW_{12} rather than time periods, will be used to indicate the response of Jeanerette soil to subsurface drainage.

The Jeanerette silty clay loam soil responded favorably to subsurface drainage as indicated by the differences in SEW_{12} values among the four treatments (Table 1). Average annual SEW_{12} values for the subsurface drained tracts were significantly less than values for the non-drained check for all drain spacings (Table 1). Average annual SEW_{12} values were 63 percent less (from 253 inch-days to 95 inch-days) for drains spaced 135-ft apart, 81 percent less (from 253 inch-days to 48 inch-days) for drains spaced 90-ft apart, and 93 percent less (from 253 inch-days to 18 inch-days) for drains spaced 45-ft apart.

The average water table depth during the times that the water table was within 12 inches of the soil surface can be calculated by dividing mean SEW_{12} values by the number of days in the period and subtracting this value from 12 inches. For example in 1980, the SEW_{12} value for the non-drained check was 337 inch-days while the time period that the water table was within 12 inches of the soil surface was 57.6 days (Table 1). Consequently, the average water table depth was $(12 - (337/57.6)) = 6.15$ inches from the soil surface during this time period.

Sugarcane requires a large amount of water, but saturated soil conditions in the soil profile for long time periods can reduce yield. Cane yields varied considerably during this study (Table 2) with the highest yields from the subsurface drained tracts being produced in 1981 and the lowest yields being produced in 1990. The highest yield from the non-drained tract was produced in 1980 and least yield was produced in 1990 (Table 2). Our main interest, however, is yield differences between drain spacing treatments and between the subsurface drained and non-drained treatments.

Average cane yields were 30.5, 30.4, 28.3, and 26.3 T/A from the 45-, 90-, and 135-ft spacings and the non-drained check, respectively (Table 2). Differences in average cane yields among the three drain spacing treatments were not significant but differences in average yields between drained and non-drained treatments were significant at the five-percent significance level. Average yields from the subsurface drained treatments were 3.43 T/A (13 percent) higher than yields from the non-drained treatment (Table 2). Individually, cane yield differences between drain spacing treatments and the non-drained check were 4.2 T/A (16 percent higher) from the 45-ft spacing, 4.1 T/A (15.6 percent higher) from the 90-foot spacing, and 2 T/A (7.6 percent higher) from the 135-ft spacing.

For three years (1984, 1986, and 1987) there was little or no yield response to subsurface drainage while for six years (67 percent of the time) there was a positive cane yield increase for subsurface drainage. The greatest yield differences between subsurface drained and non-drained treatments occurred in 1990 when cane yields from the drained treatments were from 76 to 100 percent greater than yields from the non-drained treatment. This large yield difference occurred the growing season following a severe freeze in December, 1989, after harvest. This freeze was followed by above-average rainfall in the early part of 1990 and high water table (high SEW_{12} values) in the non-drained tract (Table 1 and Figure 4). The combination of freezing temperatures and wet soil damaged the cane stand in the non-drained area severely, consequently cane yield from this treatment was very low in 1990, only 13.8 T/A (Table 2). Cane yields from the subsurface-drained tracts in 1990 were below normal for first-stubble yields but were much higher than those from the non-drained check (Table 2). Yield differences between drained and non drained treatments in 1990 were attributed to improved drainage during the rainy, wet periods following the freeze rather than by any effect during the freeze. Apparently the subsurface drained areas provided a favorable environment for the sugarcane after the freeze, while the high fluctuating water table and wet soil in the non-drained treatment created an unfavorable environment. Consequently, yields were less from the non-drained treatment.

Significantly greater cane yields for subsurface drainage occurred in three other years (1981, 1982, and 1989) during the test period. Cane yield increases attributed to subsurface drainage were 10.5 T/A in 1981; 10.4 T/A in 1982; and 6.9 T/A in 1989. The higher yields in 1981 and 1982 are attributed to the effects of drainage as indicated by SEW_{12} (Tables 1 and 2). In 1989, the SEW_{12} may not have been a factor in yield since it was only 33 inch-days in the non-drained treatment and 0 in the drained treatments, which is not enough difference to adversely affect yields. The higher yields from the subsurface drained tracts, however, could result from cumulative soil profile improvement during the 11-year period with subsurface drainage, such as improved aeration.

Although the threshold SEW_{12} value to cause significant sugarcane yield decrease is not known, data from this experiment indicate that it is probably greater than 95 inch-days annually (Table 1 and Table 2). Unlike most crops that have 75 to 120-day growing seasons, sugarcane has a growing season in Louisiana of approximately 270 days (nine months). Furthermore, two ratoon crops are normally grown following the first crop; consequently, annual SEW_{12} values, rather than 270-day SEW_{12} values (growing season only), should be used to determine threshold SEW_{12} values to prevent decline of sugar yield. Also particular emphsis should be placed on SEW_{12} values during the time when sugarcane is most susceptible to high water tables, such as during the dormant-to-early-growth stage when the crop susceptibility factor is 0.40 (Gayle, et al., 1987).

Stalk population and stalk weight are parameters that influence cane yield. Stalk population data collected during this experiment are shown in Table 3 and stalk weight data are shown in Table 4. Overall statistical analysis indicated that stalk populations and stalk weights were not significantly different among drain spacing treatments (Tables 3 and 4). When individual years were considered, stalk populations were much higher in the drained areas than in the non-drained areas in other years (Tables 3 and 4). For example, in 1980, 1989, and 1990, all drained treatments had higher stalk populations than did the non-drained tract (Table 3). In 1981, 1982, and 1985, all drained treatments had higher stalk weights than did the non-drained tract (Table 4). In 1990, the stalk weight of the non-drained treatment was much higher, more than one-pound per stalk higher, than the drained treatments (Table 4). The stalks were larger and heavier partially because of the low stalk populations, but some of the stalk weight came from the excess green leaves that were left on the stalks. The height of the stalks in the non-drained area was not sufficient for the mechanical harvester to top normally, thus, green leaves were left on the stalks and this caused an unusually high (biased) stalk weight for the non-drained treatment in 1990. Burning, after cutting and placing the cane on heap rows, removed the relatively dry leaves but not the moist green ones. Consequently, the stalk weight of the non-drained treatment was unusually high in 1990.

It was not clear why stalk populations in the drained treatments were much greater than those in the non-drained treatment some years while stalk weights in the drained treatments were higher than those in the non-drained treatment in other years. It appears that sugarcane is like many other crops in that stalk weight varies inversely with stalk population. To further explore this relationship, the stalk population and stalk weight data were regressed. The square of the correlation coefficient (r^2) for this regression was 0.26 when all nine years of data were used and

0.55 when only the six years when cane yields were increased (1980, 1981, 1982, 1985, 1989, and 1990) were used. The slope of the line that fit the data best was negative in both cases, indicating that the weight of the stalks decreased as plant population increased. A regression of cane yields (X) and stalk population (Y) showed a linear correlation with an r^2 of 0.59. A regression of cane yield (X) and stalk weight (Y) data showed a linear correlation with an r^2 of only 0.177.

Sugar yields varied considerably with the highest yields being produced in 1989 and the lowest yields being produced in 1990 (Table 5). Yields from the 45-ft and 90-ft drain spacings were similar most years. In the first crop cycle (1980-1982), yields from the 135-ft spacing were consistently higher than those from the non-drained area but less than yields from the 45-ft and 90-ft drain spacings. In the second crop cycle (1984-1987), yields for the non-drained treatment were slightly greater than yields for the drained treatments some years (Table 5). In general, differences in sugar yield among treatments were small during the second crop cycle.

In the third crop cycle (1989-1990), yields among the three drain spacings were similar, but they were consistently greater than those from the non-drained area (Table 5). The highest sugar yields during the entire experiment occurred in 1989 and were caused by an unusually high sugar content rather than high cane weight. The high sugar content was attributed to favorable weather (dry, cool weather conditions) and low water table during the cane ripening period.

Average sugar yields from all nine crops during this experiment were 5383, 5372, 5157, and 4446 lb/A from the 45-, 90-, and 135-ft spacings, and the non-drained check, respectively (Table 5). Yields among the three drain spacing treatments did not differ significantly at the five-percent level of significance (Table 5). However, average sugar yields from the subsurface drained treatments were 858 lb/A (19.3 percent) greater than yield from the non-drained treatment and this difference was significant at the one-percent significance level (Table 5). Individually, sugar yield differences between drain spacing treatments and the non-drained check were 937 lb/A (21 percent) greater for the 45-ft spacing, 926 lb/A (20.8 percent) greater for the 90-foot spacing, and 711 lb/A (16 percent) greater for the 135-ft spacing.

To determine any negative bias that might be caused by the 1990 crop, which was a ratoon crop following a severe freeze, all yield data were analyzed both including and excluding the 1990 crop. These analyses indicated no adverse influence of the 1990 crop.

The two parameters that determine sugar yield are cane biomass and the sugar concentration in the cane. Cane mass is shown in Table 2 while sugar concentration of the cane is shown in Table 6. Sugar concentration of the cane, reported in Table 6, is a commercially recoverable value, which is 13 percent less than the theoretical sugar content. Average sugar concentrations of the cane from the drained treatments were greater than that from the non-drained treatment (Table 6) but only the sugar concentrations from the 45-ft and the 135-ft spacing treatments were significantly greater than those from the non-drained treatment at the five-percent level of significance. Apparently the low sugar concentration of the cane from the 90-ft spacing treatment in 1986 was the primary reason the sugar content of the 90-ft spacing treatment was not significantly greater than that from the non-drained treatment (Table 6).

A regression of cane on sugar mass resulted in a relationship described by equation $Y = 449.5 + 60.8X$, where Y = sugar yield in lbs/A and X = cane mass in T/A. This equation is valid only for a range of cane yields between 13.8 T/A and 41.3 T/A. The r^2 value was 0.639, which means that 64 percent of the variation in sugar yield was explained by this relationship. A regression analysis of sugar yield and cane sucrose content was performed but a linear relationship was not readily evident.

The volume of water drained from the experimental sites via subsurface drainage was relatively large. Observations indicated that the cane might be suffering from drought stress at some times during the summer but water flowed readily from the subsurface drains, which were located less than three feet from the cane's roots. We observed on only two occasions during the 12-year period no flow from the drain outlet.

Flow from the drained tracts varied from 12.8 inches in 1981 to 37.9 inches in 1983 (Table 7). Average annual drain outflow was 23 inches, which was 48 percent of rainfall (Table 7). The subsurface drains were, no doubt, draining water from more than just the soil profile above the drain lines. This was readily evident during some months when the volume of water measured from the drain lines exceeded the combined volume of rainfall and the volume of thewater storage capacity of the soil. The experimental site is relatively low in elevation, less than 5 feet above sea level, and it is located within a few miles of the marshes along the edge of theGulf of Mexico. It is apparent that the subsurface drains impacted the water table outside the experimental areas far more than just half the distance between drains, which is normally used to estimate the area of influence of subsurface drains.

The amount of electrical power required to pump drain outflow from the sumps into a surface drainage ditch during the experimental period are shown in Table 7. The annual average electrical power used was 2059 kwh (176 kwh/A). The average volume of drain outflow pumped per unit of electrical energy was 3471 gal/kw. If electrical energy cost $0.08/kwh, the average annual cost for pumping drain outflow into a surface drainage ditch would be $14/A/yr.

The sugar yield increase measured during this experiment and attributed to subsurface drainage, may encourage farmers in Louisiana to install subsurface drainage if the cost can be justified. Subsurface drainage installation costs were determined for several drain spacings and soil types in Louisiana by Carter et al. (1992), and Carter and Camp (1994a,b). System costs and justification requirements for the Jeanerette soil drainage system similar to the one used in this experiment are summarized in Table 8. Only the value of crop yield increases attributed to subsurface drainage was considered in determining whether subsurface drainage can be justified. Although recognized as benefits, the value of improved cropping efficiency and improved machinery trafficability were not considered in the analysis.

Average sugar yield increases attributed to improved drainage were 936 lb/A from the 45-ft spacing, 926 lb/A from the 90-ft spacing, and 711 lb/A from the 135-ft drain spacing (Table 2). Using 1994 sugar prices for a owner/operator, the values of these yield increases were $124/A, $122/A, and $94/A, from the 45-, 90-, and 135-ft drain spacings, respectively. As with any capital expense, the cost for installing subsurface drainage must be paid by the increased sugar yield before a return on the investment is achieved with length of the pay-back period depending upon the useful system life. The number of crops (average yields) required to offset installation costs for subsurface drainage (before a return on the investment can be achieved), is six for the 45-ft spacing, and four for the 90-ft and the 135-ft spacings.

Often cash is not available to fund drain installation and a loan is required to pay initial costs. In this case, income from increased sugar yields is used to pay the loan and the amortization period will probably be limited to 10 years (decided by the lending institution) instead of the useful life of the drainage system, which is usually more than 20 years. Assuming an interest rate of 10 percent and an amortization period of 10 years, the costs of the drainage systems used in this experiment are $1077/A, $644/A, and $498/A for the 45-ft, 90-ft, and 135-ft spacings, respectively (Table 8). Because eight sugar crops are normally grown in a 10-year period in Louisiana, the yield increase in eight sugar crops must be sufficient to make ten annual payments before the system installation cost is justified. The average crop yield increase needed to justify the system installation cost is 1022 lb/A, 606 lb/A, and 473 lbs/A for systems with drains spaced 135-, 90-, and 45-ft, respectively (Table 8). The required yield increase was exceeded on the 90-ft and 135-ft drain spacing treatments but not on the 45-ft spacing treatment (Table 8). Consequently, the cost of installing subsurface drainage can be justified for the 90-ft and 135-ft drain spacings but not for the 45-ft spacing.

In addition to installation costs, there is a cost for maintenance, pump replacement, and electricity at sites where pumped (rather than gravity) drain outlets are used. Electricity cost is approximately $14/A/yr. Pump replacement and maintenance cost is estimated at about $10/A/yr. Consequently an additional increase of 237 lbs/A of sugar would be required to offset these operating costs. Yield increases from the 90- and 135-ft drain spacing treatments were sufficient to justify both the cost of installing drains and operating costs.

The statistical analysis showed no significant difference in cane and sugar yields among the three drain spacing treatments, which means there was no significant yield advantage to spacing drains closer than 135-ft. Thus, the recommended drain spacing for Jeanerette silty clay loam soil is 135 ft unless the trafficability benefit of closer spacing is desired: then the 90-ft drain spacing is recommended. The 1994 cost of systems with drain spacings of 135-ft and 90-ft was readily justified by increased sugar yields at the 1994 price for sugar (Table 8). In some cases, the ability to perform field operations soon after a rain may be as important as a yield increase and would allow more efficient use of farm machinery and labor.

SUMMARY

Three subsurface drain spacings were evaluated on Jeanerette silty clay loam soil planted to sugarcane. The number of days the water table was within 12 inches of the soil surface (high water table) and calculated SEW_{12} values were used to evaluate effectiveness of subsurface drainage. The average number of days the water table was within 12 inches of the soil surface annually was 3.8, 7.1, 13. 1, and 49.4 days for the 45-ft, 90-ft, 135-ft, and non-drained areas, respectively. Average annual SEW_{12} values were 18, 48, 95, and 253 inch-days for the 45-ft, 90-ft, 135-ft, and non-drained areas, respectively. Differences in average days of high water table and SEW_{12} values among three drain spacing treatments were not significantly different but differences between drained and non-drained treatments were significant, indicating that this soil responded favorably to subsurface drainage.

Average cane yields from the subsurface drained areas varied from 28.3 to 30.5 T/A but were not significantly different among the three drain spacing treatments. Yields from the subsurface drained treatments were significantly greater (2.0 T/A to 4.2 T/A greater) than those from the non-drained check. Average sugar yields (5157 - 5383 lbs/A) were not significantly different among the three drain spacing treatments. Sugar yields from the subsurface drained treatments were 711 - 937 lbs/A and significantly greater (up to 21 percent greater) than yields from the non-drained check.

From the yield standpoint, there was no advantage to spacing subsurface drains closer than 135 ft. Thus, the recommended drain spacing for Jeanerette silty clay loam is 135 feet. If the ability to perform field operations with machinery soon after a rainstorm is important, a 90-foot drain spacing is recommended. Subsurface drainage system costs with drains spaced 90-ft and 135-ft were justified by the value of increased sugar yields attributed to subsurface drainage, assuming the 1994 price for sugar and costs for drainage installation.

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Table 1. Anual rainfall, SEW_{12}, and the number of days the water table was within 12 inches of the soil surface.

		Drain spacing						Non-drained	
		45-ft		90-ft		135-ft		Check	
Year	Rain	SEW	days	SEW	days	SEW	days	SEW	days
	(in.)	inch-days (number)							
1980	66.50	78	(22.3)	165	(23.4)	292	(42.5)	337	(57.6)
1981	46.02	0		15	(1.8)	33	(5.4)	204	(29.7)
1982	70.52	0		34	(7.3)	122	(25.3)	384	(70.9)
1983	64.72	--		--		--		--	
1984	51.42	36	(3.5)	42	(5.0)	52	(6.4)	343	(57.1)
1985	61.14	9	(1.6)	51	(6.0)	77	(9.9)	259	(51.4)
1986	50.71	0		7	(1.3)	17	(4.0)	45	(10.7)
1987	57.60	42	(7.0)	119	(19.5)	266	(24.6)	420	(82.4)
1988	59.96	--		--		--		--	
1989	57.64	0		0		0		33	(10.7)
1990	42.99	0		0		0		248	(74.2)
Mean	57.20	18	(3.8)a*	48	(7.1)b	95	(13.1)c	253	(49.4)d

* Mean SEW_{12} and days followed by the same letter are not significantly different at $P = 0.05$.

Table 2. Cane yields from subsurface-drained and non-drained treatments

Year	Drain Spacing 45-ft	 90-ft	 135-ft	Non-drained Check
	tons cane per acre			
1980	35.8	34.8	29.2	33.6
1981	40.1	41.3	34.8	30.8
1982	29.6	28.2	24.6	19.2
1983	--	--	--	--
1984	29.5	29.0	30.3	31.5
1985	28.1	28.2	24.6	25.7
1986	29.5	30.3	27.5	29.3
1987	18.8	17.7	19.0	20.6
1988	--	--	--	--
1989	38.7	38.8	36.9	31.9
1990	24.2	25.2	27.7	13.8
Mean	30.5a*	30.4a	28.3a	26.3b

*Mean cane yields followed by the same letter are not significantly different at *P* = 0.05.

Table 3. Stalk populations from subsurface-drained and non-drained treatments.

Year	Drain Spacing 45-ft	Drain Spacing 90-ft	Drain Spacing 135-ft	Non-drained Check
	stalks per acre			
1980	38850	37147	34858	33517
1981	37331	31218	33568	37679
1982	23875	28958	30652	25991
1983	--	--	--	--
1984	27872	27405	29851	28208
1985	27200	26547	24571	28040
1986	28955	26099	28899	27499
1987	24456	23000	23130	24941
1988	--	--	--	--
1989	35220	34286	33767	28241
1990	18444	19714	19956	7234
Mean	29134a*	28264a	28806a	26817a

*Mean stalk populations followed by the same letter are not significantly different at $P = 0.05$.

Table 4. Stalk weights from subsurface-drained and non-drained treatments.

Year	------------------------- Drain Spacing ------------------------- 45-ft	90-ft	135-ft	Non-drained Check
	-----------------	(lb/stalk)	-----------------	
1980	1.85	1.90	1.68	2.00
1981	2.15	2.65	2.08	1.65
1982	2.50	1.94	1.62	1.47
1983	--	--	--	--
1984	2.13	2.13	2.02	2.25
1985	2.07	2.13	2.03	1.83
1986	1.98	2.26	1.84	2.04
1987	1.54	1.56	1.74	1.66
1988	--	--	--	--
1989	2.20	2.27	2.18	2.26
1990	2.73	2.78	2.80	3.89
Mean	2.13a*	2.18ab	2.00a	2.12a

*Mean stalk weights followed by the same letter are not significantly different at $P = 0.05$.

Table 5. Sugar yields from subsurface-drained and non-drained treatments.

	------------------------- Drain	Spacing-------------------------		
Year	45-ft	90-ft	135-ft	Non-drained Check
	-----------------------------------lbs per acre-----------------------------------			
1980	5251	5270	5053	4603
1981	7100	7105	6687	5349
1982	4810	4969	3511	2776
1983	--	--	--	--
1984	4826	5176	5602	5137
1985	5701	6041	5123	5296
1986	5252	4857	5159	5116
1987	4860	4149	4728	4712
1988	--	--	--	--
1989	7495	7190	7293	5710
1990	3150	3592	3261	1319
Mean	5383a*	5372a	5157a	4446b

*Mean sugar yields followed by the same letter are not significantly different at $P = 0.05$. Yield differences between drained and non-drained treatments were significant at $P = 0.01$.

Table 6. Sugar content of cane from subsurface-drained an non-drained treatments.

Year	45-ft	90-ft	135-ft	Non-drained Check
	Drain Spacing			
	lbs sugar per ton of cane			
1980	147	151	173	137
1981	177	172	192	174
1982	163	176	143	145
1983	--	--	--	--
1984	164	178	185	163
1985	203	214	208	206
1986	178	160	188	175
1987	258	234	249	229
1988	--	--	--	--
1989	194	185	198	179
1990	130	143	118	96
Mean	179 a*	179ab	184a	167b

*Mean sugar contents followed by the same letter are not significantly different at $P = 0.05$.

Table 7. Drain outflow from subsurface-drained tracts and electrical power required to pump outflow into a surface drainage ditch.

Year	Rainfall (inches)	Drain Outflow (inches)*	Electricity (kwh)	
			Total	Per Acre
1980	66.50	**	**	**
1981	46.02	12.83	1146	98
1982	70.52	30.68	2761	236
1983	64.72	37.94	3405	291
1984	51.42	28.68	2562	219
1985	61.14	29.88	2644	226
1986	50.71	19.82	1825	156
1987	57.60	18.44	1696	145
1988	59.96	20.05	1778	152
1989	57.64	17.54	1591	136
1990	42.99	13.99	1205	103
Mean	57.20	22.98	2059	176

* Equivalent depth of drain outflow for area drained.

** Drain outflow measurements began in 1981.

Table 8. Sugar yield increases needed to justify the cost of installing subsurface drainage in Jeanerette silty clay loam soil.

Drain Spacing	Drain Install Cost	Interest Cost*	Total Cost	Annual Payment	Yield Increase Needed**	Yield Increase Observed
(ft)	($/A)	($/ha)	($/ha)	($/yr)	(lb/A)	lb/A
45	679	398	1077	108	1022	936
90	406	238	644	64	606	926
135	314	184	498	50	473	711

* Based on 10 percent interest and 10-year amortization period.

** Eight sugar crops are normally grown in a 10-year period in Louisiana. Thus, the needed yield increase in eight sugar crops must be sufficient to make ten payments to justify the cost of installing subsurface drains.

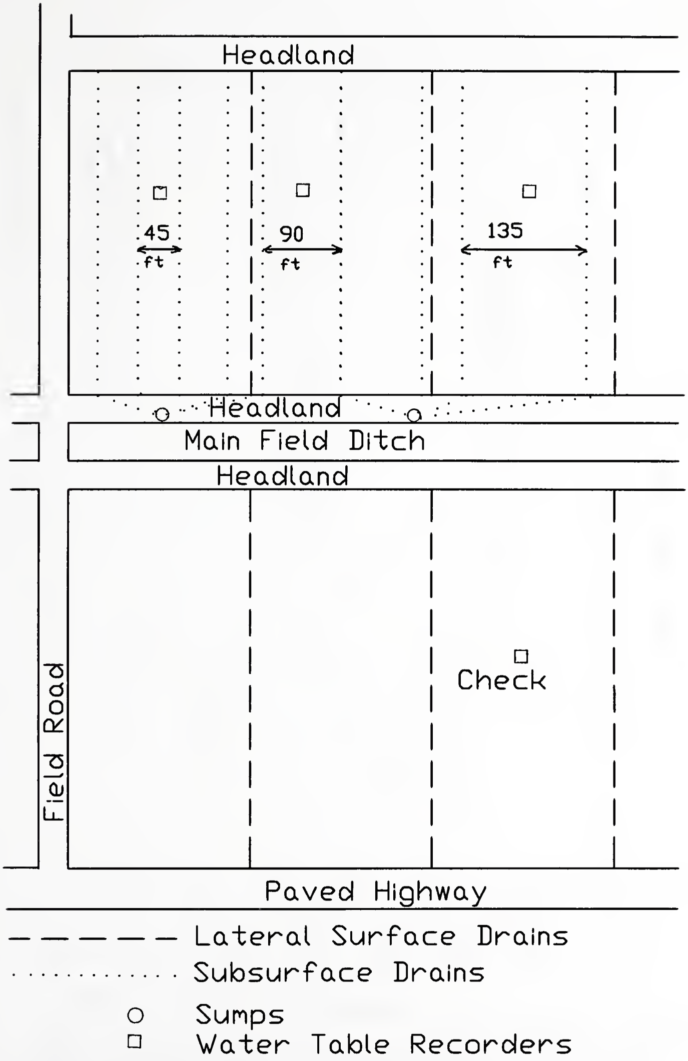

Figure 1. Layout of subsurface drainage experiment in Iberia Parish, LA

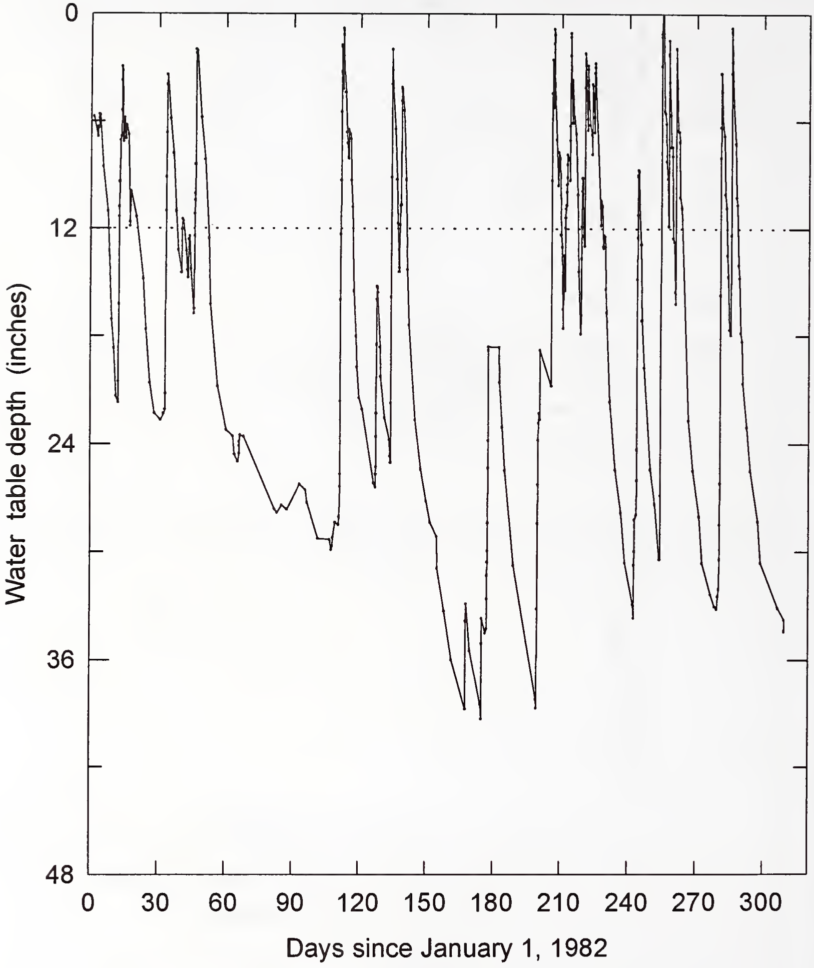

Figure 2. Water table depth for the check treatment in 1982. The water table was within 12 inches of the soil surface 17 times for a total of 70.9 days. SEW_{12} was 384 inch-days.

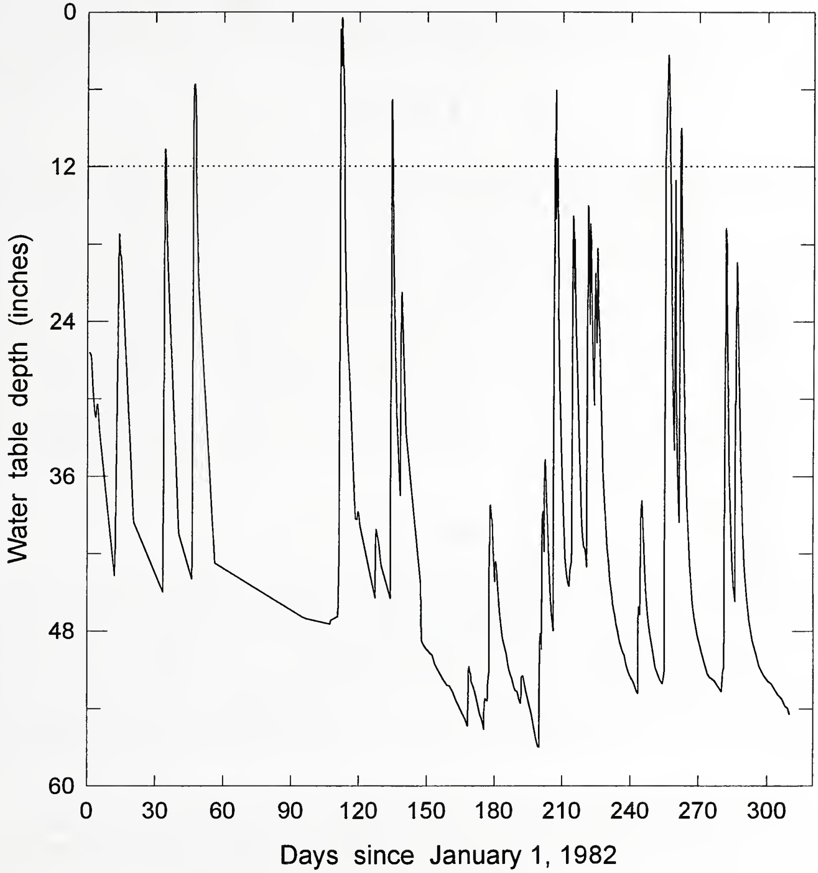

Figure 3. Water table depth for the 90-foot drain spacing treatment in 1982. The water table was within 12 inches of the soil surface eight times for a total of 7.3 days. SEW_{12} was 34 inch-days.

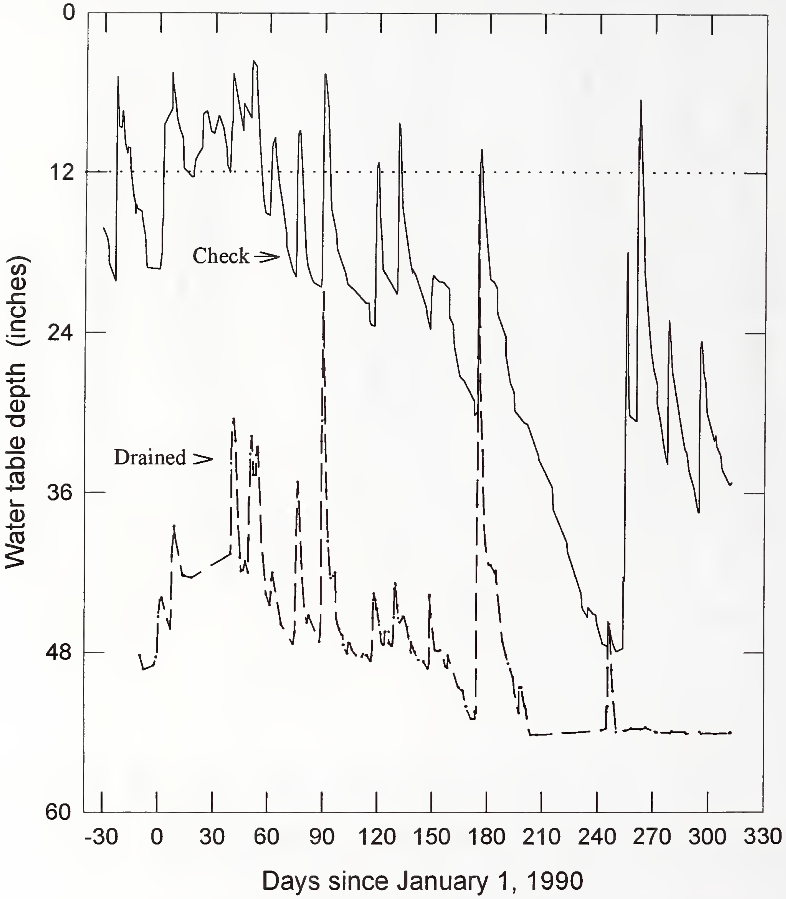

Figure 4. Water table depths for subsurface drained (90-ft spacing) and non-drained (check) in 1990. The water table in the drained area never came within 12 inches of the soil surface while the water table in the check was within 12 inches of the soil surface 10 times for a total of 74.2 days. SEW was 248 inch-days.

FIELD TEST FOR LEAF COLD TOLERANCE IN SUGARCANE

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ABSTRACT

Improvement of cold tolerance in sugarcane (a complex hybrid of *Saccharum* spp.) would ensure stable productivity of this crop in cooler regions and prevent yield loss in subtropical regions following serious freezes. Fifteen clones selected from backcross progeny of hybrids derived from commercial cane x *Saccharum spontaneum* plus two check cultivars were used to evaluate the stability of leaf cold tolerance of sugarcane genotypes at freezing temperatures under field conditions and to classify genotypes based on both genotypic values and stability statistics. Plants were rated for cold tolerance based on the percent green leaf tissue following exposure to freezing temperatures. Two plant cane and two first ratoon crops were evaluated. Parametric and nonparametric approaches were used to classify genotypes by integrating cold tolerance mean and stability. Considerable differences in parametric and nonparametric stability statistics for cold tolerance existed among genotypes. Cluster analyses grouped the genotypes that were differentiable in terms of mean and stability. Integration of mean and stability of cold tolerance by using parametric and nonparametric approaches should improve the effectiveness of selecting cold tolerance in sugarcane.

INTRODUCTION

In temperate latitudes and at relatively high elevations in the tropics, temperatures periodically drop below freezing. Such conditions may result in serious damage to sugarcane crops. Freeze injury can cause significant reduction in growth of young cane and deterioration in juice quality of mature cane. Differences in cold tolerance among *Saccharum* spp. and commercial clones have been observed (Arceneaux et al., 1951; Brandes, 1937; Breaux and Irvine, 1976; Dunckelman and Breaux, 1971; Irvine 1978 and 1983; Tai and Miller, 1986). The development of freeze resistant sugarcane cultivars has been a major objective at the Sugarcane Field Station at Canal Point, Florida, since the early 1950's (Arceneaux et al., 1951; Tai and Miller, 1986 and 1993).

Sugarcane cold tolerance may be classified into three categories (Arceneaux et al., 1951; Irvine, 1967 and 1978): 1) resistance of leaves and buds when exposed to frost or light freeze conditions; 2) resistance of stalks to freezing and subsequent deterioration under moderate freeze conditions; and 3) ability of cane to ratoon after being exposed to severe winters. In south Florida, where severe winters are infrequent, categories 1 and 2 are more important than category 3. Irvine (1978) also classified damage to cane plants following exposure to freezing temperatures into four types: damage of leaves of young plants (at -2.7° C), damage of leaves and terminal buds of mature cane (at -3.3 to -3.9° C), damage of the upper quarter to half of the stalk (at -4.4 to -5.0° C), and damage of the entire stalk tissue (at -5.0 to -6.0° C).

Cold tolerance of sugarcane is a complex trait that is difficult to improve. Selection for cold tolerance in sugarcane has not been successful due to the loss of cold tolerance genes during the course of nobilization, a process through which hardy but inferior wild species are improved by crossing and backcrossing with superior noble cane (*S. officinarum* L.) or commercial cultivars (hybrids of *Saccharum* spp.) (Brandes, 1939; Brandes and Matz, 1939). Another reason is that the genetic component for cold tolerance is relatively small in comparison to the genotype x environment (GE) interaction component (Tai and Miller, 1986 and 1993). Detection of differences among genotypes is very difficult. Selection for cold tolerance based on mean performance from field tests in several locations over several years has been suggested (Tai and Miller, 1986 and 1993). Development of an appropriate selection strategy is needed to increase the efficiency of breeding for the improvement of cold tolerance in sugarcane. Parametric and nonparametric approaches (Lin et al., 1986; Hühn, 1979 and 1990; Kang and Pham, 1991) have been proposed to integrate yield with stability in order to improve selection efficiency.

The objectives of this study were to evaluate the stability of leaf cold tolerance of sugarcane genotypes at freezing temperatures under field conditions and to classify genotypes using both genotypic values and stability statistics.

MATERIALS AND METHODS

Fifteen genotypes (US 87-1001 to US 87-1015) derived from backcrosses of hybrids of commercial cane x *S. spontaneum* and two cultivars (CP 65-357 and NCo 310) were evaluated for their responses to freezing under field conditions in two plant-cane and two first-ratoon crops. Minimum temperatures experienced in the plant-cane crops were -4.4°C during 1988/89 and -3.7°C during 1993/94. For the first-ratoon crops, minimum temperatures recorded were -4.8°C during 1989/90 and -5°C during 1994/95, respectively. Cultivars CP 65-357 (moderately cold tolerant) and NCo 310 (tolerant) were used as standards because they have demonstrated superior cold tolerance under commercial production conditions (Breaux and Irvine, 1976; Irvine, 1978). The experiment was carried out at the University of Florida Institute of Food and Agricultural Sciences Agronomy Farm, Gainesville, Florida (29°38'N), in a randomized complete block design with 4 replications. Each clone was planted as a single-row plot, which was 1.82 m wide and 1.52 m long. Clones were rated for cold tolerance by estimating the amount (percent) of green leaf tissue on mature plants about one week after freeze injury (Arceneaux et al., 1951; Irvine, 1978). Each plot was rated twice (once in the afternoon and once the following morning) by two individuals. An average of the ratings by the two individuals was used for all statistical analyses. Other categories of cold tolerance were not rated.

A combined analysis of variance was conducted. Parametric and nonparametric stability analyses were used to evaluate the differences for cold tolerance among genotypes. The parametric statistics of stability calculated were: the variance of a genotype across environments (S_i^2) (Lin et al., 1986), Plaisted's (1960) variance component for GE (genotype x environment) interaction ($\Theta_{(i)}$), Wricke's (1962) ecovalence (W_i^2), Shukla's (1972) stability variance (σ_i^2), and Finlay and Wilkinson's (1963) regression coefficient (b_i). The formulae for computing these five stability statistics are summarized in Table 1.

Nonparametric statistics (Hühn, 1979 and 1990) were calculated as follows:

$$S_i^{(1)} = 2\Sigma\Sigma\,|r_{ij} - r_{ij'}|/[n(n-1)]$$

$$S_i^{(2)} = \Sigma(r_{ij} - r_{i.}/n)^2/(n-1)$$

$$S_i^{(3)} = \Sigma(r_{ij} - r_{i.}/n)^2/(r_{i.}/n)$$

$$S_i^{(6)} = \Sigma\,|r_{ij} - r_{i.}/n|/(r_{i.}/n)$$

where r_{ij} is the rank of the ith genotype in the jth environment, $r_{i.}$ is the total of ranks over all environments for ith genotype, and n is number of environments, in this particular case, 4 winters.

Genotypes were classified based on similarity measures using both genotypic effects and GE interaction. Cluster analyses (SAS, 1988) with Euclidean distance (Hanson, 1970; Johnson, 1977) and standardized distance (Fox and Rosielle, 1982) were also performed (Table 1).

RESULTS AND DISCUSSION

A significant interaction between genotypes (clones) and environments was detected. This suggested that genotypes responded differentially to environments for cold tolerance (analysis of variance is not shown). Genotypic variance was small. This is significant in that these results are similar to those reported previously (Tai and Miller, 1986 and 1993). Therefore, effective selection for cold tolerance should be based on both mean cold tolerance and genotypic stability at several locations and over several years.

The parametric stability analyses indicate that S_i^2 ranged from less than 1 (US 87-1015) to greater than 100 (US 87-1009 and US 87-1011) (Table 2). It was positively correlated ($r = 0.86$) with a genotype's mean cold tolerance rating. Three other stability statistics, $\Theta_{(i)}$, W_i^2, and σ_i^2, were nearly equivalent in ranking the genotypes. The stability statistics showed that US 87-1001, US 87-1003, US 87-1005, US 87-1010 and US 87-1013 were the five most stable, whereas US 87-1006, US 87-1007, US 87-1009, US 87-1011 and US 87-1015 were the five least stable genotypes.

Results also show that correlation between b_i and percent green leaf tissue was positive and significant ($r = 0.82$). According to Finlay and Wilkinson (1963), a genotype with $b < 1.0$ has above average stability and is specifically adapted to low-performing environments; a genotype with $b > 1.0$ has below average stability and is specifically adapted to high-performing environments; and a genotype with $b = 1.0$ has average stability and is well-adapted to all environments, meaning that its mean performance varies with that of the environment. Both US 87-1009 and US 87-1011 had high average cold tolerance and above average stability, whereas US 87-1001, US 87-1002, US 87-1007, US 87-1012, US 87-1015, NCo 310, and CP 65-357 had low average cold tolerance but below average stability (Table 1). These genotypes of the latter group suffered considerable freeze damage under both light and moderate freezing temperatures. US 87-1006, US 87-1010, and US 87-1013 appeared to do well in a light freeze, and performed better than average under a moderate freeze. US 87-1004, US 87-1008, US 87-1009, US 87-1011, and US 87-1014 suffered only minor damage under light freeze temperature, but exhibited light to moderate freeze injury under conditions of a mild freeze. These results indicate that sugarcane breeders must develop cultivars with high stability as well as superior cold tolerance.

According to Lin et al. (1986), $\Theta_{(i)}$, W_i^2, and σ_i^2 belong to the stability statistics of Group B while S_i^2 belongs to Group A and b_i belongs to Group C. Each of these three groups will be most useful under its own specific circumstances. If we want to compare the relative stability in cold tolerance among the group of sugarcane clones and response patterns over the range of the test environments, a combination of Groups B and C may provide us with the best information.

All four nonparametric stability statistics, $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$, and $S_i^{(6)}$, ranked genotypes similarly (Table 3). They ranked US 87-1002, US 87-1012, CP 65-357 and NCo 310 among the top five genotypes. $S_i^{(1)}$ and $S_i^{(2)}$ selected US 87-1011 whereas $S_i^{(3)}$ and $S_i^{(6)}$ selected US 87-1013 as the best genotype. The statistic $S_i^{(1)}$ ranked US 87-1013 and NCo 310 identically. CP 65-357, NCo 310, and US 87-1002 were the most stable, whereas US 87-1007, US 87-1009 and US 87-1015 were the least stable.

Parametric and nonparametric statistics did not produce the same stability rankings among genotypes. The nonparametric stability statistics indicated that US 87-1002, US 87-1012, CP 65-357, and NCo 310 would be selected (if the top 5 genotypes were identified with each statistic). They were stable because they suffered severe damage under all levels of freezes. Under this situation, these nonparametric stability statistics varied very little and rank change occurred only within a small range. Therefore, nonparametric statistics could not be used effectively when genotypic differences in cold tolerance among clones are very small and produce a narrow range of rank change.

Cold tolerance was closely associated with S_i^2, b_i, and $S_i^{(6)}$, and was moderately associated with $\Theta_{(i)}$, W_i^2, and σ_i^2 (Table 4). The mean rating was poorly associated with $S_i^{(1)}$, $S_i^{(2)}$, and $S_i^{(3)}$. The statistic S_i^2 appeared to have the same pattern of correlation with other stability statistics as did mean cold tolerance rating. $\Theta_{(i)}$, W_i^2, and σ_i^2 were strongly correlated with each other. Kang et al. (1987) suggested that either W_i^2 or σ_i^2 is needed for partitioning GE interactions. All three statistics were moderately associated with $S_i^{(6)}$. They were not significantly associated with b_i, $S_i^{(1)}$, $S_i^{(2)}$, and $S_i^{(3)}$. All four nonparametric stability statistics were positively correlated.

A cluster dendrogram based on the Euclidean distance as a similarity measure is shown in Figure 1A. Seven clusters were obtained when the splitting level of the dendrogram was set using a normalized root-mean-square (RMS) distance of 0.2 between clusters (SAS, 1988). Three genotypes, US 87-1002, US 87-1012, and US 87-1015, were similar to CP 65-357 (moderately cold tolerant) and, in turn, these four genotypes were similar to NCo 310 (tolerant). US 87-1001, US 87-1003, and US 87-1010 formed one cluster and US 87-1006, US 87-1013, US 87-1004, US 87-1005 and US 87-1014 formed another cluster. Both clusters were more similar to CP 65-357 and NCo 310 in genetic and stability performance than the other three genotypes, US 87-1008, US 87-1009, and US 87-1011, which were not clustered with the remaining genotypes until the highest fusion level.

The cluster dendrogram based on the standardized distance as a similarity measure is also shown in Figure 1B. If the splitting level of the cluster dendrogram was also set using a RMS distance of 0.2 between clusters, there were 6 clusters. Three genotypes, US 87-1012, US 87-1015, and US 87-1007, each formed a separate, single-genotype cluster. These three genotypes were not clustered with one another or the remaining genotypes until near the highest fusion level. Six genotypes, US 87-1001, US 87-1003, US 87-1010, US 87-1002, US 87-1006, and US 87-1013 shared the same cluster with CP 65-357. Three genotypes, US 87-1004, US 87-1011, and US 87-1014 were in the same cluster with NCo 310. The dendrogram indicates that US 87-1005, US 87-1008, and US 87-1009 were more similar to NCo 310 than to CP 65-357.

Thus, Euclidean and standardized distances, used as criteria of measuring the genotypic similarity, produced two different genotypic clusterings. The most distinct difference was that, using the Euclidean distance, three genotypes, US 87-1007, US 87-1012 and US 87-1015, were clustered with CP 65-357 and NCo 310 at the low fusion level. However, using the standardized distance, these same three clones were not clustered with these check genotypes until near the highest fusion level. The Euclidean distance method for clustering genotypes may be more revealing about the similarity of genotype including average cold tolerance and stability than the standardized distance method. By including well-known cold tolerance cultivars as standards, genotypes selected for advancement should be equal to or better than the level of cold tolerance and stability of these standards.

Difficulties experienced in the transfer of desired genes from *S. spontaneum* to sugarcane during the nobilization process are commonplace (Roach, 1978 and 1984). It appears that cold tolerance is no exception. Recurrent selection for cold tolerance by using combined gene pools of *S. spontaneum* plus hardier commercial cultivars may be an effective strategy to prevent loss of cold tolerance genes in the course of backcrossing or nobilization. Also, induction of chromosome breakage with physical and chemical mutagens to increase recombination in early backcross generations or nobilizations should be explored. Kang and Pham (1991) used maize (*Zea mays* L.) yield trials to demonstrate the simultaneous selection for high yielding and stable crop genotypes. Integration of stability and cold tolerance by using parametric and non-parametric approaches should improve the selection and evaluation techniques for cold tolerance in sugarcane.

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Table 1. A summary of equations for the five stability statistics and for the two similarity measures.

Equation†

Stability statistics:

$$S_i^2 = \Sigma(X_{ij} - \Sigma X_{i.}/q)^2/(q-1)$$

$$\Theta(i) = \frac{-p}{(p-1)(p-2)(q-1)}\Sigma(X_{ij} - \Sigma X_{i.}/q - \Sigma X_{.j}/p + \Sigma X_{..}/pq)2 + SS(GE)\ddagger/[(p-2)(q-1)]$$

$$W_i^2 = \Sigma(X_{ij} - \Sigma X_{i.}/q - \Sigma X_{.j}/p + \Sigma X_{..}/pq)^2$$

$$\sigma_i^2 = \frac{p}{(p-2)(q-1)}\Sigma(X_{ij} - \Sigma X_{i.}/q - \Sigma X_{.j}/p + \Sigma X_{..}/pq)^2 - SS(GE)\ddagger/[(p-1)(p-2)(q-1)]$$

$$b_i = \frac{\Sigma(X_{ij} - \Sigma X_{i.}/q)(\Sigma X_{.j}/p - \Sigma X_{..}/pq)}{(\Sigma X_{.j}/p - \Sigma X_{..}/pq)^2}$$

Similarity measures (between genotypes i and i' in environment j):

Euclidean distance: $d^2(A)_{ii'} = \Sigma(X_{ij} - X_{i'j})^2$

Standardized distance: $d_s^2(A)_{ii'} = \Sigma[(X_{ij} - \Sigma X_{i.}/q)/S_i\# - (X_{i'j} - \Sigma X_{i'.}/q)/S_{i'}\#]$

---

† X_{ij} represents the observed mean cold tolerance value of genotype (clone) i (i = 1, .., p) in environment j (j = 1, ..., q).

‡ $SS(GE) = \Sigma(X_{ij} - \Sigma X_{i.}/q - \Sigma X_{.j}/p + \Sigma X_{..}/pq)^2$.

# $S_i^2 = \Sigma(X_{ij} - \Sigma X_{i.}/q)^2/(q-1)$ and $S_{i'} = \Sigma(X_{i'j} - \Sigma X_{i'.}/q)^2/(q-1)$.

Table 2. Mean cold tolerance rating (%) and four parametric stability statistics for individual genotypes from the cold tolerance field test.

Genotype	Mean Rating*	S_i^2	$\Theta_{(i)}$	W_i^2	σ_i^2	b_i
US 87-1001	7.87#	17.57	8.99#	12.49#	4.70#	0.74
US 87-1002	3.56	7.43#	10.40	20.41	7.68	0.51
US 87-1003	5.84	39.47	8.42#	9.25#	3.48#	1.14#
US 87-1004	6.56	53.39	9.47	15.14	5.70	1.35
US 87-1005	5.94	36.68	7.63#	4.78#	1.80#	1.12#
US 87-1006	6.10	34.17	23.11	92.20	34.70	1.09#
US 87-1007	6.47	12.23#	18.13	64.09	24.12	0.36
US 87-1008	9.27#	72.01	14.26	42.21	15.89	1.52
US 87-1009	10.21#	126.44	27.15	114.98	43.28	2.05
US 87-1010	7.22#	29.97	8.50#	9.68#	3.64#	0.97#
US 87-1011	11.25#	128.84	26.68	112.36	42.29	2.11
US 87-1012	4.47	13.09	9.25	13.93	5.24	0.47
US 87-1013	6.18	32.69	6.97#	1.06#	0.40#	1.07#
US 87-1014	5.25	48.30	9.12	13.19	4.96	1.28
US 87-1015	4.90	0.74#	19.22	70.22	26.43	0.10
CP 65-357	2.19	3.03#	14.25	42.17	15.87	0.31
NCo 310	3.67	12.14#	9.10	13.05	4.91	0.64

* Cold tolerance rating based on % green leaf tissue.

Selected genotypes (assuming that the top 5 genotypes were selected).

Table 3. Ranks of cold tolerance rating and non-parametric stability statistics for the cold tolerance field test.

Genotype	Rating* Rank	$S_i^{(1)}$	$S_i^{(2)}$	$S_i^{(3)}$	$S_i^{(6)}$
US 87-1001	4#	4.33	16.25	9.28	4.95
US 87-1002	15	1.83#	2.25#	0.51#	0.83#
US 87-1003	11	7.17	32.25	9.44	4.20
US 87-1004	6	4.67	13.67	4.83	3.29
US 87-1005	10	4.50	14.25	4.89	3.09
US 87-1006	9	4.67	16.67	5.56	3.11
US 87-1007	7	7.83	38.91	16.10	6.48
US 87-1008	3#	5.17	18.92	11.10	6.53
US 87-1009	2#	5.33	17.99	10.80	6.40
US 87-1010	5#	3.83	8.92	4.28	3.68
US 87-1011	1#	2.17#	2.92#	3.18	4.73
US 87-1012	14	3.00#	5.99#	1.64#	1.64#
US 87-1013	8	3.17#	6.92	2.52#	2.30#
US 87-1014	12	8.00	32.91	8.40	4.09
US 87-1015	13	7.17	35.08	13.58	5.55
CP 65-357	17	1.17#	0.92#	0.17#	0.43#
NCo 310	16	3.17#	6.25#	1.36#	1.38#

* Cold tolerance rating based on % green leaf tissue.

# Selected genotype (assuming that the top 5 genotypes were selected).

Table 4. Correlation coefficients among mean rating, parametric and non-parametric stability statistics for a set of sugarcane genotypes from the field cold tolerance test.

	Mean Rating	S_i^2	$\Theta_{(i)}$	W_i^2	σ_i^2	b_i	$S_i^{(1)}$	$S_i^{(3)}$	$S_i^{(6)}$
S_i^2	0.86**								
$\Theta_{(i)}$	0.52*	0.58*							
W_i^2	0.51*	0.58*	1.00**						
σ_i^2	0.52*	0.58*	1.00**	1.00**					
b_i	0.82**	0.95**	0.38	0.38	0.38				
$S_i^{(1)}$	0.14	0.02	0.07	0.07	0.07	0.02			
$S_i^{(2)}$	0.07	-0.07	0.11	0.11	0.11	-0.10	0.98**		
$S_i^{(3)}$	0.37	0.13	0.33	0.33	0.33	0.03	0.86**	0.90**	
$S_i^{(6)}$	0.73**	0.49*	0.47	0.47	0.47	0.40	0.69**	0.69**	0.90**

*, ** Significant at the 0.05 and 0.01 probability level, respectively.

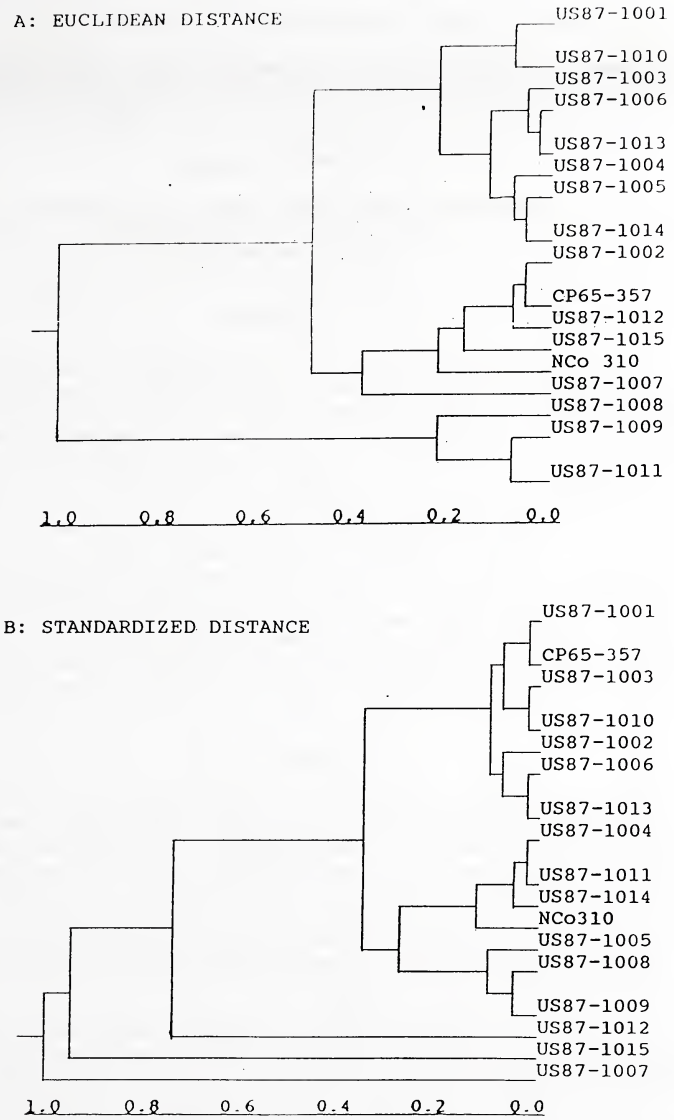

Figure 1. Cluster dendrograms based on two similarity measures, Euclidean (A) and standardized (B) distances, of 17 genotypes used in cold tolerance field tests.

TOPPING HEIGHT AND SUGAR YIELD: EFFECTS OF CULTIVAR, CROP YEAR, AND USE OF THE CHEMICAL RIPENER GLYPHOSATE

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ABSTRACT

A 3-year field study (1991-1993) with seven experiments was conducted in the plant- and first-ratoon crops of three sugarcane cultivars, CP 65-357, CP 70-321, and CP 72-370, to examine the effects of the severity of topping (from no topping to topping 5 cm above the apical meristem or bud to 41 cm below the bud in 15-cm increments) on sugar yield (kg ha^{-1} of theoretical recoverable sugar per hectare) and its components, cane yield (Mg ha^{-1}) and yield of theoretical recoverable sugar (TRS) per ton of cane (kg/Mg), as influenced by cultivar, crop year, or the use of the chemical ripener glyphosate [isopropylamine salt of N-(phosphonomethyl)glycine]. Sugar yield response to topping severity was similar for all cultivars regardless of crop year or the use of glyphosate. The highest sugar yield was obtained with no topping and, although differences were not always significant, the greater the severity of topping, the greater the loss in sugar yield. Although there was generally an increase in TRS (approximately 2.5%) with each incremental reduction in the topping height, any increase in sugar yield (kg ha^{-1}) was more than offset by a decrease in the cane yield (approximately 6%), regardless of cultivar, crop age, or use of glyphosate. However, the practice of no topping has potential adverse effects on processing which can ultimately contribute to sugar losses in the factory and lower sugar quality.

INTRODUCTION

It has been recognized since 1935 that the topping height has considerable effect upon the quality of juice from harvested sugarcane (Arceneaux, 1935; Legendre, 1993). Mechanical harvesting has led to the concept of "average topping" rather than the older practice of topping each stalk at the uppermost mature internode (Coleman, 1959). When sugarcane stalks were topped too low by the whole-stalk "soldier harvester", mature cane on the taller stalks was left in the field resulting in a loss in the yield of cane. However, when the stalks were topped too high, immature cane on the shorter stalks would be delivered to the mill with a resulting loss of sugar yield (Davidson, 1965). This relationship is most important early in the milling season when relatively immature cane is harvested.

Proper setting of the topping height by the harvester operator has an important effect on the quality of harvested sugarcane. It was recognized during the 1940s that the change to mechanical harvesting led to an increase in cane trash, including tops, with the harvested cane. This resulted in a drop in normal juice extraction and boiling house efficiency (Legendre, 1992). Using the sugarcane purchase contracts in force prior to 1975, higher topping generally increased net cane (cane without trash) yields (Anonymous, 1968). However, because of the generally lower sucrose content and purity associated with higher topping, overall cane quality as well as the value of each net ton was reduced. On the other hand, with lower topping, the reductions in net cane yields more than offset the gains from higher quality and purity factors, resulting in reduced total payments to the grower for the cane delivered to the mill for processing.

The milling of cane with tops reduced the available sucrose and increased the amount of nonsucrose solids, resulting in a loss of recoverable sugar (Coleman, 1959; Irvine, 1977). Davidson (1965) noted that, to obtain the highest sugar recovery, the cane should be topped to exclude those portions of the stalk in which the average juice purity was lower than the final molasses purity.

The response of sugarcane to the chemical ripener glyphosate is primarily in the top one-third of the stalk (Baird and DeStefano, 1977; Legendre et al., 1994). Consequently, growers using glyphosate have a tendency to harvest cane without removing much, if any, of the top in order to maximize sugar yield. The growth retarding properties of the compound cause a reduction in cane yield although there is generally an overall increase in sugar yield because of the increase in the yield of theoretical recoverable sugar (TRS) per ton of cane even when the topping height is 10 cm below the bud. Legendre et al. (1994) noted that while glyphosate increased sucrose yield, the higher topping height caused an increased concentration in the juice of total polysaccharide, dextran, and leucoanthocyanin when compared to untreated but mature sugarcane. This can ultimately contribute to sugar losses in the boiling house and lower sugar quality. The present study was the first comprehensive study initiated to examine the effects of the topping height on sugar yield considering cultivars, crop year, and the use of the chemical ripener glyphosate.

MATERIALS AND METHODS

Five field experiments were conducted at the Sugarcane Research Unit Farm near Houma, Louisiana in 1991 in the plant-cane crop (experiment 1), in 1992 in the first-ratoon crop (experiments 4 and 5), and in 1993 in the first-ratoon and plant-cane crops (experiments 6 and 7, respectively) on silt loam soils (fine-silty, mixed, nonacid, thermic, Typic Fluvaquent). Two additional experiments were conducted in 1992 in the first-ratoon crop at Breaux Farms (experiment 2a), Little-Texas (experiment 2b), Boudreaux Brothers Farms (experiment 2c), Laurel Valley Plantation, Inc. (experiments 3a and 3b), and Godfrey Knight Farm (experiment 3c) on silt loam soils. Sugarcane cultivars common to all experiments were CP 65-357, CP 70-321, and CP 72-370. These cultivars represented 79% of the planted area in sugarcane in Louisiana in 1994 (Faw, 1995). The letters a, b, and c following experiments 2 and 3 refer to the cultivar(s) harvested at each location to include CP 65-357, CP 70-321, and CP 72-370, respectively. In experiments 2a-c and 3a-c, the chemical ripener glyphosate (POLADO L[1]) was applied aerially at the recommended rate of 0.34 kg acid equivalent (ae)/ha in a spray volume of 47 L/ha approximately 35 days before harvest. See Table 1 for additional data about each experiment.

At harvest, 240 (experiment 1) or 300 (experiments 2-7) mature stalks of each cultivar were serially selected along the row in standing cane, cut at the soil surface, stripped of all leaves, and removed from the field with the green tops intact. Stalks of each cultivar were divided at random into four (experiment 1) or five (experiments 2-7) 60-stalk lots. Prior to topping, stalk length was measured by cultivar in each experiment to determine the average initial stalk height. This facilitated simulation of mechanical harvesting and the concept of "average topping". The tops of the stalks in each lot of experiments 2-7 were then removed at one of five heights (treatments): 1) No topping (tops and leaves left attached to the stalk); 2) An average of five (5) cm above the apical meristem (bud); 3) An average of ten (10) cm below the bud; 4) An average of twenty-five (25) cm below the bud; and 5) An average of forty-one (41) cm below the bud. Stalks of experiment 1 were divided into only four treatments, nos. 2-5. Treatments were then divided at random into six subsamples (replications) with each replication containing 10 stalks.

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[1] A proprietary name is necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

Each subsample was weighed to determine mean stalk weight prior to passing it through a prebreaker to prepare the sample for analysis according to the procedure described by Legendre (1992). A 1 kg sample of the prepared cane was pressed for 2 minutes at a pressure of 246 kg/cm^2. The press separated the sample into juice (approximately 80% extraction) and residue (bagasse), both of which were analyzed, the former for Brix (by refractometer) and pol (by saccharimeter), and the latter for moisture (by drying for 24 hours at 150°C). The Brix, sucrose, and fiber percent cane and yield of theoretical recoverable sugar (TRS) per ton of cane were calculated from these analyses. Net cane yields (Mg ha^{-1}) represent the product of mean stalk weight and an assumed stalk population per hectare of 74,000. Sugar yield (kg ha^{-1}) was calculated by multiplying cane yield by yield of sugar per ton of cane. The analyses were divided into three parts for interpretation of ANOVA for sugar yield at the various levels of topping and considering the effects of cultivars, crop year, and the use of the chemical ripener glyphosate. Data were analyzed according to standard analysis of variance methods and least significant difference (LSD, P=0.05) was used for mean separation (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

For the plant-cane crops harvested in 1991 and 1993 (experiments 1 and 7) there was no interaction between the topping height and sugar yield for the three cultivars. Hence, all cultivars behaved similarly for the two experiments during both years. Accordingly, data were combined for the three cultivars and the two years (Table 2). The highest sugar yield was obtained with no topping, and although the differences were not always significant, as the topping height was reduced, sugar yield also decreased.

There were some differences in response found in the first-ratoon crops harvested in 1992 and 1993 (experiments 4, 5, and 6). All three cultivars behaved similarly during a given year with respect to the topping height but there was a significant interaction between years and topping height. In 1992, the results were similar to those found in the plant-cane crops, with the highest sugar yield obtained with no topping and as the topping height was reduced, sugar yield also decreased (Table 2). Although the highest sugar yield was again obtained with no topping in the 1993 experiments, there was no difference between sugar yield for the four remaining levels of topping, with the lowest sugar yield numerically still occurring with the most severe topping height (41 cm below the bud) (Table 2). However, due to these differences, data are presented for the two years separately which does not seriously alter the final results which generally show that as the topping height was reduced, sugar yield also decreased (Table 2).

Where glyphosate was applied to the first-ratoon crops in 1992 (experiments 2a-c and 3a-c), all three cultivars again behaved similarly. The highest sugar yield was obtained with no topping and as the topping height was reduced, sugar yield again decreased, although the differences were not always significant (Table 2). Further, it was noted that there was no interaction in response (sugar yield) between the six dates of harvest and the severity of topping.

For all seven experiments maximum sugar yield occurred with no topping regardless of cultivar although as the topping height was reduced there was a corresponding increase in the yield of theoretically recoverable sugar (TRS) per ton of cane and a decrease in cane yield (Table 2). Fiber content was significantly higher for all cultivars with no topping; however, there was no difference in the level of fiber as the severity of topping increased from 5 cm above to 41 cm below the bud (data not presented).

Although the data suggest that sugar yield is maximized with no topping, such a practice comes with potential adverse effects on processing. As early as 1935, Arceneaux (1935) reported that the analysis of the juice from mill cane grown under Louisiana conditions could be regulated within certain limits by discarding varying proportions of comparatively immature tops when the cane was harvested. He stated that the extent to which it was economically desirable to increase the sugar content of mill cane by discarding increasing proportions of the tops varied with conditions, including: the market value of sugar and molasses, the cost of transporting the cane, and the conditions under which the sugarcane was purchased from the grower. Under the then sliding-scale contracts employed in Louisiana for the purchase of cane prior to 1975 (Anonymous, 1968), in which the purchase price decreased rapidly as the percentage of sucrose decreased below the basic percentage established in the contract as the standard (usually 11%), proper topping was of even greater importance to the grower. Arceneaux (1935) further stated that the most advantageous benefits of topping may be expected from comparatively immature cane, as judged by the relative increase in TRS and by the amount of available sugar in portions of the stalk discarded. However, the cultivars used in the present study mature earlier and have a significantly higher level of sucrose than the cultivars grown in the 1930s (Legendre, 1995). Also, the use of the chemical ripener glyphosate can significantly increase the average sucrose and purity content of most cultivars especially early in the harvest season (Legendre and Finger, 1987). In the present study, the difference between no topping and the removal of 41 cm of the cane stalk increased TRS by approximately 11 kg/Mg when averaged across cultivars and experiments (Table 2).

By lowering topping height, reductions in net cane yields more than offset the gain from higher quality and purity factors, resulting in reductions in standard cane yields (Davidson, 1965). This reduction in standard cane yields was small when compared to the reduction in cane to be loaded, hauled to the mill, and processed. In the present study, stalk weight and ultimately net cane yields decreased an average of 4.4 Mg ha^{-1} (or about 6%) while TRS increased 3.4 kg/Mg (or about 2.5%) with each 15-cm reduction in the topping height as an average of all cultivars and experiments (Table 2). In 1989, Richard (unpublished data) showed the same tendency for the cultivar CP 70-321 when harvested late in the harvest season. He reported a significant increase in net cane yields when topping at 25 cm above but no difference when topping at 20 cm below the uppermost mature internode. Conversely, he also stated that the TRS was significantly higher when topping at 20 cm below but significantly lower when topping at 25 cm above the uppermost mature internode.

Sucrose recovery is not simply a function of concentration, but is affected by fiber, extraction, resorption, and by the presence of substances that inhibit crystallization, i.e. glucose and fructose (reducing sugars), inorganic ash, and the concentration of total polysaccharide and starch (Irvine, 1977). According to Osgood and Teshima (1979), the presence of other soluble carbohydrates such as glucose and fructose in immature or unripe cane decreases the purity and adversely affects the recovery of sugar. Legendre et al. (1994) found that there was higher inorganic ash with no topping, regardless of the cultivar, and that the ash content of the juice could be reduced by topping. Irvine (1977) noted that total polysaccharides are less abundant in the millable stalk, and stalk segments showed a decreasing concentration from top to bottom of the stalk, with the highest concentration found in the leaves. Also, he stated that starch content varied significantly with the time of the day cane is harvested and that harvesting systems which do not effectively remove tops or green leaf blades add to the starch load in clarification.

Legendre et al. (1994) reported that glyphosate increased sucrose content, TRS, and sugar yield but decreased cane yield. However, the use of glyphosate does not come without potential adverse affects on processing, namely a reduction in the reducing sugars to ash ratio and a possible increase in total polysaccharide and dextran content which can ultimately contribute to sugar losses and lower sugar quality. However, they reported that these negative responses to the use of glyphosate can be partially offset by cultivar selection and/or removing the leaves and upper portion of the stalk by topping.

Further, if stalks and tops are milled together, the additional bagasse formed from the tops will resorb sucrose expressed from the stalks, causing losses, while the juices expressed from the tops also have the same nonsucrose solids that inhibit crystallization and are major molasses constituents; these are dextrose, levulose, gums, starch, and potassium (Irvine, 1977). The net effect of milling cane with tops is to reduce the available sucrose and increase the amount of nonsucrose solids. It was noted in the present study that both sucrose and purity content increased with lower topping while fiber content remained essentially constant once the leafy top was removed (data not presented). Significantly higher fiber content was noted in cane with the tops intact. Unlike previous methods of analysis, the prebreaker/press method (Legendre, 1992) used in this study takes into consideration the effects of fiber and nonsucrose solids on TRS which still showed that maximum sugar yield in mature cane was obtained by not topping. Richard (unpublished data) reported similar findings for the cultivar CP 70-321 harvested late in the harvest season. He stated that although there was no difference in the sugar yield between topping at 25 cm above and 20 cm below the uppermost mature internode, the maximum numerical yield occurred at the highest topping position. Both Arceneaux (1935) and Davidson (1965) noted that there were differences among cultivars in the optimum topping height on sugar yield, especially in immature cane early in the harvest season. That was not the case in the present study where all cultivars performed similarly with the highest yield coming from no topping regardless of the crop year or the use of the chemical ripener glyphosate. However, the practice of no topping has potential adverse affects on processing which can ultimately contribute to sugar losses and lower sugar quality.

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Table 1. Locations, dates, and stalk length at harvest for the various experiments.

Experiment no.	Cultivar[1]	Crop year[2]	Location[3]	Harvest date	Stalk length[4] (cm) Cultivar 1	2	3
1	Composite	PC	Ardoyne Farm	12-03-91	234	229	239
2a	CP 65-357	1st	Breaux Farm	10-22-92	167	---	---
2b	CP 70-321	1st	Little Texas	10-28-92	---	180	---
2c	CP 72-370	1st	Boudreaux Bros.	10-23-92	---	---	185
3a	CP 65-357	1st	Laurel Valley	11-05-92	215	---	---
3b	CP 70-321	1st	Laural Valley	11-05-92	---	207	---
3c	CP 72-370	1st	Godfrey Knight	11-12-92	---	---	222
4	Composite	1st	Ardoyne Farm	11-30-92	235	255	237
5	Composite	1st	Ardoyne Farm	11-30-92	250	222	262
6	Composite	1st	Ardoyne Farm	10-25-93	239	257	250
7	Composite	PC	Ardoyne Farm	11-01-93	279	264	259

[1] Composite = CP 65-357, CP 70-321, and CP 72-370.

[2] PC = plant-cane crop; 1st = first-ratoon crop.

[3] Sugarcane Research Unit Farm near Houma, LA.

[4] Stalk length for cultivars 1 = CP 65-357, 2 = CP 70-321, and 3 = CP 72-370, were measured from apical meristem (bud) to base of stalk: basis for standardizing topping height in each experiment.

Table 2. Effect of topping height on sugar yield as affected by crop year and use of the chemical ripener glyphosate (mean of three cultivars CP 65-357, CP 70-321, and CP 72-370) (experiments 1-7)[1].

Topping level[2]	Sugar yield (kg ha^{-1})	Cane yield (Mg ha^{-1})	Yield of theoretical recoverable sugar (kg/Mg)
Plant-cane crop [experiments 1 (yr 91) and 7 (yr 93)][3]			
1	10,738 A	91.7 A	117.1 B
2	8,284 B	73.4 B	112.9 C
3	8,216 BC	70.8 BC	116.0 BC
4	7,930 BC	67.4 CD	117.7 AB
5	7,840 C	64.6 D	121.4 A
LSD (0.05)	443	4.8	4.1
First-ratoon crop [experiments 4 and 5 (yr 92)]			
1	11,630 A	84.1 A	138.3 C
2	10,599 B	75.1 B	141.1 BC
3	10,219 B	71.1 B	143.7 B
4	9,672 C	66.4 C	145.7 AB
5	9,495 C	63.7 C	149.1 A
LSD (0.05)	505	5.5	4.7
First-ratoon crop [experiment 6 (yr 93)]			
1	7,394 A	77.0 A	96.0 C
4	6,874 B	60.8 BC	113.1 A
3	6,819 B	63.8 B	106.9 B
2	6,768 B	65.9 B	102.7 B
5	6,665 B	56.5 C	118.0 A
LSD (0.05)	505	6.0	5.2
First-ratoon crop w/glyphosate [experiments 2a-c and 3a-c (yr 92)]			
1	10,183 A	72.6 A	140.3 D
2	9,301 B	64.3 B	144.7 C
3	9,029 B	61.2 BC	147.5 BC
4	8,554 C	57.6 CD	148.5 AB
5	8,280 C	54.7 D	151.4 A
LSD (0.05)	344	3.7	3.2

[1] Means followed by the same letter are not significantly different at the $P = 0.05$.

[2] 1 = no topping; 2 = topping 5 cm above apical meristem (bud); 3 = topping 10 cm below bud; 4 = topping 25 cm below bud; 5 = topping 41 cm below bud.

[3] Unbalanced data. Data for topping level 1 for experiment 7 only.

JOHNSONGRASS (*Sorghum halepense*) AND SUGARCANE RESPONSE TO ASULAM APPLICATION[1]

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ABSTRACT

In field studies conducted over 2 yr, johnsongrass arising from seed (1992) or rhizomes (1993) and three sugarcane cultivars, `CP 70-321, `CP 72-370', and `LCP 82-89', were treated during the plant-cane growing season with asulam at 3.7 kg ai/ha on April 15, May 1, May 15, or June 15. In the first year, late season johnsongrass panicle counts in sugarcane plots averaged across asulam application dates were comparable for cultivars LCP 82-89 and CP 72-370 and 44 and 33% lower, respectively, than for CP 70-321. In the second year, johnsongrass panicle counts were highest in plots planted to LCP 82-89. Regardless of johnsongrass source or cultivar, johnsongrass panicle counts were reduced by at least 50% when asulam was applied compared with a nontreated check. Even though visual injury was greatest for CP 72-370 both years, late-season johnsongrass control, sugarcane stalk populations and heights, and cane yields were not affected. Averaged across cultivars, yields of plant-cane were equivalent when asulam was applied in April or May and greater than when applied in June both years. For the May 15 asulam application, plant-cane yields were 17% (1992) and 14% (1993) greater than for the June 15 application. Plant-cane yields for the June 15 application were higher than the nontreated check only in 1992. **Nomenclature:** Asulam, methyl[(4-aminophenyl)sulfonyl]carbamate; sugarcane, *Saccharum* interspecific hybrids `CP 70-321', `CP 72-370', and `LCP 82-89'; johnsongrass, *Sorghum halepense* (L.) Pers.

INTRODUCTION

In 1993, an estimated 148,000 ha of sugarcane were harvested for sugar in Louisiana, which provided $234 million in gross farm income (Anonymous, 1993b). Three sugarcane crops are typically harvested from a single planting in Louisiana. The first production year is referred to as plant-cane with successive crops referred to as first and second ratoons. Johnsongrass is one of the most troublesome weeds in Louisiana sugarcane (Bridges and Anderson, 1992). Because the sugarcane drill is not disturbed during the 3-yr crop cycle, heavy infestations of rhizomatous johnsongrass can develop causing significant reductions in sugarcane stalk populations in the ratoon crops. With the presence of high densities of johnsongrass, yields of ratoon crops can be reduced 44 to 58% (Ali, et al.,1986; Millhollon and Fanguy, 1985; Richard, 1990; and Richard and Griffin, 1993).

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Metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one], terbacil [5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4-(1*H*,3*H*)-pyrimidinedione], trifluralin [2,6-dinitro-*N*,*N*-dipropyl-4-(trifluoromethyl)benzenamine], and pendimethalin [*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] are labeled for PRE control of seedling johnsongrass, but provide little control of rhizomatous johnsongrass (Anonymous, 1993a). Asulam is the only herbicide labeled for POST johnsongrass control. Control of johnsongrass with asulam is often inconsistent and seldom exceeds 70 to 80% (Millhollon and Fanguy, 1989; Richard, 1990; and Richard and Griffin, 1993). Johnsongrass growth stage at time of asulam application (Richard, 1989; and Richard, 1990) and sensitivity to washoff by rainfall (Bruff, et al., 1995; and Richard, 1986) contribute to the variability in weed control. Even though johnsongrass is not completely controlled with asulam, tillering of sugarcane is enhanced, resulting in increased stalk populations and yield (Millhollon, 1976; Richard, 1990; and Richard and Griffin, 1993).

Sugarcane cultivar recommendations are made after considering such characteristics as fertilizer utilization efficiency (Gascho, et al., 1986), growth rates and relative sugar content (Glaz, et al., 1989), ratooning ability (Milligan, et al., 1990), and herbicide tolerance (Matherne and Millhollon, 1973; Osgood, et al., 1972; and Richard, 1989). Tolerance of sugarcane cultivars to asulam differs (Millhollon and Fanguy, 1989; and Richard, 1990). Frequent cultivation of the sides of the 1.8 m wide raised sugarcane beds restricts johnsongrass development to the row top. Asulam is generally applied to this johnsongrass as a 90-cm band with ground equipment. Application of asulam April 15 or May 1 is most beneficial for sugarcane yields (Richard, 1990). Recommended timing of asulam application is when johnsongrass is around 46 cm tall and before flowering, which, depending on climatic conditions, is usually in mid to late April (Anonymous, 1993a). Rainfall or johnsongrass resurgence may necessitate June applications of asulam; however, late-season applications of asulam in June or July may increase phytotoxicity to sugarcane (Richard, 1990). Of the sugarcane cultivars grown in Louisiana, CP 72-370 is considered most sensitive to asulam, whereas CP 70-321 is one of the more tolerant cultivars (Anonymous, 1993a; and Millhollon and Fanguy, 1989).

Limited research has been conducted to compare cultivar response to asulam application dates, especially with the newly released cultivar LCP 82-89. This research was initiated to characterize the growth response and yield of LCP 82-89 plant-cane to April through June asulam applications as influenced by the presence of johnsongrass.

MATERIALS AND METHODS

Field studies were conducted in 1992 at St. Gabriel, LA and in 1993 near Houma, LA. Sugarcane cultivars CP 70-321, CP 72-370, and LCP 82-89 were planted in late September or early October of the year prior to initiation of the studies. Johnsongrass at St. Gabriel was established by planting seed over the newly planted line of sugarcane. At Houma, johnsongrass rhizome pieces 6 to 15 cm long with 4 to 10 buds were placed approximately 5 cm deep directly over the newly planted sugarcane. Atrazine [6-chloro-*N*-ethyl-*N'*-(1-methylethyl)-1,3,5-triazine-2,4-diamine] at 2.2 kg ai/ha was applied PRE to sugarcane in March and at 2.2 kg/ha in late June both years. Prior to the June layby treatment, row sides were cultivated and soil was pulled to the base of the sugarcane plants.

Asulam at 3.7 kg/ha was applied April 15, May 1, May 15, or June 15 (± 3 d) when johnsongrass height to the last visible collar was 3 to 15, 10 to 51, 25 to 76, or 61 to 122 cm, respectively. The range in size was due to variation in emergence of johnsongrass from seed (1992) and rhizomes (1993). Asulam treatments were applied in a spray volume of 190 L/ha at 210 kPa pressure with crop oil concentrate[2] added at 1% (v/v). Either a tractor-mounted compressed air sprayer or a CO_2-pressurized backpack sprayer was used to apply asulam treatments. Sprayer boom configuration, which covered a 90-cm band on the row top, consisted of three nozzles, one of which was positioned directly over the sugarcane row. The two remaining nozzles, spaced 30 cm from the center nozzle, were mounted on 15-cm drops and angled in toward the canopy center.

Asulam efficacy in providing late-season johnsongrass control was assessed by counting panicles in each plot in mid-August. At the same time, harvestable sugarcane stalk counts (number/plot) and height measurements (15/plot) were determined. Sugarcane stalks were considered harvestable if the collar of the youngest leaf below the whorl was at least 1 m above the soil surface. Visual sugarcane injury ratings were made July 1, 1992 and July 15, 1993, which corresponded to either 2 or 4 wk after the last asulam application, respectively. Injury was based on chlorosis and necrosis of plant tissue and growth reduction compared with the nontreated check. A rating scale of 0 to 100% where 0 = no injury and 100 = plant death was used.

Sugarcane was mechanically harvested in early November. In the harvesting operation, sugarcane stalks and johnsongrass residues for each plot were heaped into a single pile. Excessive fodder, as well as johnsongrass residues, were removed from the pile by burning prior to weighing the stalks to determine gross cane yields (kg/ha). After weighing the pile, 15 stalks were selected at random from each plot, weighed, and then crushed in a three-roller mill. Theoretical sugar yields were determined using standard methodology described previously (Richard and Griffin, 1993).

A split-plot experimental design with whole plots as sugarcane cultivars and subplots as asulam application dates was used in each study. Treatments were replicated five times. Plots consisted of three adjacent rows 15.3 m (St. Gabriel) and 13.4 m (Houma) long. Analysis of variance indicated a significant year (location) interaction for all variables, and data for each year are reported separately. A date of asulam application by cultivar interaction was noted for johnsongrass panicle counts (1993) and sugarcane stalk heights (1992 and 1993). Sugarcane stalk population and yield data are presented as an average across cultivars and dates of asulam application. Fisher's protected LSD at the 0.05 level of probability was used to separate treatment means.

RESULTS AND DISCUSSION

Johnsongrass Response

Johnsongrass panicle counts were similar regardless of cultivar or asulam application date in 1992. Averaged across cultivars, asulam application the first year reduced panicle counts at least 50% compared with the nontreated check (Table 1). Panicle counts when asulam was applied in June were less than for the earlier applications, which was a reflection of a shorter treatment to date collection interval and delayed johnsongrass maturity rather than a reduction in johnsongrass biomass. Averaged across asulam application dates, johnsongrass panicle counts were greater in CP 70-321 than the other cultivars.

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[2] Agri-Dex, a mixture of 83% paraffinic mineral oil and 17% polyoxyethylene sorbitan fatty acid ester, Helena Chemical Co., 5100 Poplar Ave., Memphis, TN 38137.

In contrast, a cultivar by date of asulam application interaction was noted for johnsongrass panicle counts in 1993. For each cultivar, panicle counts were equivalent when asulam was applied in April or May and less than when application was made June 15 (Table 1). For all asulam application dates, panicle counts were at least 53% less than for the nontreated check. When asulam was applied in June 1993, panicle counts were more than twice as high in LCP 82-89 than in CP 72-370 or CP 70-321. When asulam was not applied, panicle counts were 57% higher in LCP 82-89 than CP 72-370 and 44% higher in CP 72-370 than CP 70-321. Higher johnsongrass panicle counts in LCP 82-89 in 1993 may be attributed to earlier rhizome johnsongrass emergence in the spring than seedling johnsongrass. In addition, of the three cultivars evaluated, LCP 82-89 is the slowest to emerge in the spring. Hence, rhizome johnsongrass should be more competitive with LCP 82-89 than the other cultivars.

The difference in johnsongrass response to the June 15 asulam application between years is probably related to the 4 cm of rainfall received within 48 hr of the June 15 application the second year at Houma. Critical rainfree periods for the control of johnsongrass with asulam depend on the size of the johnsongrass and rainfall intensity with the longer rainfree periods being required for mature johnsongrass subjected to heavy rainfall (Bruff, etal., 1995; Richard, 1986). The late emergence of additional johnsongrass from seed after the early asulam applications in 1992 and the size of the rhizome johnsongrass at the time of the early asulam applications in 1993 may account for the greater johnsongrass control observed when asulam was applied in April and early May the second year compared with the first year.

Sugarcane Response

Previous studies have shown greater sugarcane injury with asulam following June applications when temperatures during the growing season are higher (Millhollon and Fanguy, 1989; Richard, 1990). In 1992, visual sugarcane injury based on leaf chlorosis was noted only for the June 15 asulam application and was no more than 12% (data not shown). Injury was greatest for CP 72-370 and lowest for CP 70-321. In 1993, visual injury to the cultivars was noted only when asulam was applied in June. CP 72-370 had an injury rating of 25%, LCP 82-89 of 11%, and CP 70-321 of 6%. As the growing season progresses, CP 72-370 has a more erect leaf orientation than CP 70-321. With this orientation, greater spray droplet coverage of the leaf's adaxial and abaxial surfaces may enhance the potential for asulam phytotoxicity.

In preliminary greenhouse studies, leaf uptake of ^{14}C asulam from the adaxial surface was greater for CP 72-370, but translocation within the plant was less than for CP 70-321 (data not shown). These observations suggests that asulam accumulation within the foliage of CP 72-370 may be greater than in CP 70-321. The accumulation of asulam in the leaf would enhance the possibility of leaf injury and may account for the differential sensitivity of the cultivars observed in these field studies.

Even though visual injury was significant for CP 72-370, stalk height was not reduced. Differences in stalk height between cultivars and between application dates, when compared with the nontreated check, were not detected in 1992 (Table 2). Stalk heights in 1993, were greater for CP 72-370 than for LCP 82-89 and CP 70-321 at all asulam application dates (Table 2).

Tiller development early in the growing season impacts the number of stalks present at harvest. The presence of johnsongrass, especially early in the season, can reduce sugarcane tillering and ultimately harvestable stalk populations (Ali, et al., 1986). Stalk population both years were similar for the various cultivars regardless of asulam application date. In 1992, stalk populations averaged across cultivars were equivalent for the April and May asulam applications ranging from 48,000 to 49,500 stalks/ha, which was greater than for the June application by at least 17% and the nontreated check by at least 54% (Table 3). Even though injury to sugarcane occurred when asulam was applied in June, stalk population, because of the johnsongrass control, was still greater than when asulam was not applied.

In 1993, stalk populations following asulam application in April or May were greater than when applied in June by at least 10% and greater than the nontreated check by at least 12% (Table 3). Stalk population following June application that year was equivalent to when asulam was not applied because seedling johnsongrass was not present in the study conducted in Houma. In contrast, seedling johnsongrass emerging in May and June at St. Gabriel probably interfered with sugarcane tillering. As a result, sugarcane stalk populations in the June 15 asulam treatment and the nontreated check were reduced to a greater extent when compared with treatments that received April and May asulam applications. In commercial fields, a preemergence herbicide having activity on seedling johnsongrass would have been applied in late-March to limit the emergence of seedling johnsongrass (Anonymous, 1993a).

Averaged across asulam application dates, sugarcane stalk populations in 1992 for LCP 82-89 were 31 to 41% greater than for CP 72-370 and CP 70-321; stalk populations of the latter two cultivars were equivalent (Table 4). In contrast, stalk populations in 1993 were equivalent for CP 72-370 and CP 70-321, but 14 to 16% greater than for LCP 82-89. The variability in response between years for LCP 82-89 was probably related to planting date, environmental conditions during the two growing seasons, and/or its inability to compete with the earlier emerging rhizome johnsongrass present in 1993. These data indicate that even though significant foliar injury was noted for CP 72-370 following treatment with asulam, stalk population was not reduced.

Responses observed in sugarcane stalk populations were reflected in cane yield. Sugarcane cultivars responded similarly to date of asulam application both years. When asulam was applied in April or May in 1992, cane yields were equivalent and at least 11% higher than the June application and at least 51% higher than the nontreated check (Table 3). In 1993, sugarcane yields were also equivalent when asulam was applied in April or May and at least 14% greater than for application in June and the nontreated check.

Averaged across asulam application dates, sugarcane yields were equivalent for the three cultivars in 1992 (Table 4), even though differences in stalk populations among the cultivars were observed. In contrast, yields the second year were equivalent for CP 72-370 and CP 70-321 and 6 to 7% greater than for LCP 82-89. That year, yield responses were reflected in differences in stalk populations. Sugar yield response to date of asulam application closely paralleled that for sugarcane yield (data not presented). For both years, yield of sugar was equivalent when asulam was applied in April or May and greater than when applied in June and higher than the nontreated check.

Results from these studies indicate that johnsongrass emerging in spring from seed or rhizomes can be competitive with sugarcane during the plant-cane growing season and should be controlled to avoid significant production losses. Application of asulam in June increased the risk of sugarcane injury both years and did not result in an increase in cane and sugar yields in one study. In other studies, CP 72-370 has been shown to be more sensitive to herbicides than other sugarcane cultivars (Millhollon and Fanguy, 1989; Richard, 1989; and Richard, 1990). In this study, CP 72-370 was visibly injured by asulam applied in June, but injury to CP 72-370 did not hamper its ability to compete with johnsongrass following an asulam application in June. When johnsongrass infestations are heavy and CP 72-370 sugarcane is not under stress, the potential losses in cane yields associated with johnsongrass competition may be far greater than the potential losses in cane yield associated with an asulam application in June, particularly when heavy johnsongrass infestations are present in the plant-cane crop.

LCP 82-89 appears to be less sensitive to asulam injury than CP 72-370 and is either slightly more or equivalent in its sensitivity to asulam when compared with CP 70-321. These data also indicate that LCP 82-89 may be less competitive with rhizome johnsongrass than the other cultivars. This is probably related to a combination of early emergence of rhizomatous johnsongrass and slower early-season growth rate of LCP 82-89.

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Table 1. Late-season johnsongrass panicle counts as influenced by date of asulam application and sugarcane cultivars[a].

Application	1992				1993		
date	CP 70-321	CP 72-370	LCP 82-89	Avg.	CP 70-321	CP 72-370	LCP 82-89
	no./ha x 10^3						
April 15	46.6	26.9	15.1	29.5	2.0	2.9	6.9
May 1	39.8	20.0	16.1	25.3	0.4	0.4	1.2
May 15	23.3	17.6	11.5	17.5	0.8	1.2	2.9
June 15	4.7	2.9	3.2	3.6	18.3	21.2	43.6
Nontreated	67.8	54.5	56.0	59.4	41.1	59.1	92.9
Avg.[b]	36.4	24.4	20.4				
LSD (0.05)	NS				16.3		

[a] Asulam was applied POST at 3.7 kg/ha.

[b] LSD (0.05) = 7.9 to compare means for cultivars and means for application dates in 1992.

Table 2. Sugarcane stalk height as influenced by date of asulam application and sugarcane cultivars[a].

Application	1992			1993		
date	CP 70-321	CP 72-370	LCP 82-89	CP 70-321	CP 72-370	LCP 82-89
	cm					
April 15	181.0	176.7	175.6	202.4	213.6	195.1
May 1	180.4	172.6	174.0	197.7	211.0	194.4
May 15	180.0	171.5	175.9	197.2	210.3	195.4
June 15	173.1	165.5	169.5	190.8	202.5	187.3
Nontreated	173.0	175.0	173.8	198.9	212.4	191.2
LSD (0.05)	NS			8.0		

[a] Asulam was applied POST at 3.7 kg/ha.

Table 3. Sugarcane stalk population and cane yields as influenced by date of asulam application[a, b].

Application date	Stalk population 1992	1993	Cane yield 1992	1993
	------no./ha x 10^3------		-------kg/ha x 10^3------	
April 15	48.0	72.5	54.8	67.0
May 1	48.8	72.5	55.0	67.9
May 15	49.5	71.3	57.9	67.0
June 15	41.2	64.8	49.5	58.9
Nontreated	31.2	63.6	36.4	58.7
LSD (0.05)	5.0	4.5	4.6	2.5

[a] Asulam was applied POST at 3.7 kg/ha.

[b] Values represent an average across sugarcane cultivars CP 70-321, CP 72-370, and LCP 82-89.

Table 4. Sugarcane stalk population and cane yields for three cultivars as influenced by date of asulam application[a, b].

Application date	Stalk population 1992	1993	Cane yield 1992	1993
	------no./ha x 10^3------		-------kg/ha x 10^3------	
CP 70-321	37.6	72.5	51.7	65.0
CP 72-370	40.5	71.7	49.1	65.4
LCP 82-89	53.1	62.7	51.3	61.4
LSD (0.05)	9.0	4.1	NS	2.9

[a] Asulam was applied POST at 3.7 kg/ha.

[b] Values represent an average across asulam application dates of April 15, May 1 and 15, and June 15, along with a nontreated check.

EVALUATION OF PARENTAL CLONES IN BREEDING FOR RESISTANCE TO RATOON STUNTING DISEASE

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ABSTRACT

Clones selected for advancement in the Canal Point Cooperative Sugarcane Breeding Program were inoculated with *Clavibacter xyli* subsp. xyli, the causal agent of ratoon stunting disease (RSD) in separate tests over a four-year period. The purpose of this study was to evaluate our first attempts to screen for RSD resistance in the Canal Point breeding program. Plot size and number of replications varied according to selection stage (amount of seedcane available). The number of stalks sampled per clone ranged from 3 to 20. Since these were preliminary RSD ratings, only the susceptible clones, which showed >10 colonized vascular bundles (CVB) per standardized core (1 cm diameter) of stalk tissue were discarded. Seven female parents (CP 70-1133, CP 89-2149, CP 84-1322, CP 85-1025, CP 89-2319, US 90-1025 and Co 285) in the CP 92 & 93 series produced at least 10 progeny and had no progeny discarded. Six female parents (CP 76-1306, CP 86-1427, CP 86-1670, CP 87-1733, CP 85-1758, and US 88-1014) had >20% of their progeny discarded, and two female parents (CP 76-1306 and CP 87-1733) had >40% of their progeny discarded because of RSD susceptibility. All male parents with >10 progeny had at least one clone discarded based on RSD susceptibility. Among the 25 parents used as males and the four polycrosses, six clones (CP 80-1743, SP 70-1143, Akoki 22, CP 85-1491, CP 88-2045 and CP 89-2178) had >20% of their progeny discarded due to RSD susceptibility. The average number of CVB for male parents with >10 progeny ranged from 1.81 for CP 81-1238 to 6.31 for CP 88-2045. For the female parents, the average number of CVB ranged from 1.05 for US 90-1025 to 7.84 for US 88-1014. These preliminary data provide evidence that breeding for effective resistance to RSD by selection of resistant parents may be possible. Use of RSD-resistant clones as parents should increase the frequency of RSD resistance in the progeny, even if selection pressure in the routine breeding and selection program is absent.

INTRODUCTION

Ratoon stunting disease (RSD) caused by *Clavibacter xyli* subsp. *xyli* (Harrison & Davis, 1988) has been reported to cause serious yield losses in sugarcane (*Saccharum spp)* in many countries (Hughes, 1974). Although RSD can be controlled by hot-water treatment (Steindl, 1961), it is difficult to maintain RSD-susceptible cultivars in a disease-free condition. Two industries considered to have the best disease-free seedcane production schemes, with the highest degree of control over seedcane quality are those in Australia and South Africa. Roach (1987) in Australia, indicated that, in spite of considerable effort, RSD still occurred in many fields. In South Africa, Bailey et al. (1994) reported that in the best production areas, RSD occurred in about 12% of fields, while in the more tropical Pongola, 40% of the fields were infected. Loss of production due to RSD for 1993 was estimated to be 2% over all South Africa. Losses due to RSD in Florida were estimated by Dean and Davis (1990) to average 5% based on yield results obtained with four cultivars (one of which showed no significant yield loss) over a three-crop cycle (the plant cane, first-ratoon, and second-ratoon crops). Losses caused by RSD are usually due to reduced tonnages. RSD-infected sugarcane may have a higher sucrose content than healthy cane early in the harvest season because of the restricted growth. In Florida, Irey (1986) reported consistently lower sucrose content across five cultivars in heat-treated cane early in the season, but at late harvest, the sucrose content of the heated-treated cane approached or equaled that of RSD-infected cane. Because of increased cane yields, late-season sugar per acre yields in heat-treated cane were 0.4% to 21% greater than those in untreated checks of the respective cultivars.

Breeding as a means of controlling RSD was suggested by Jack Dean (personal communication, 1986) as soon as it became apparent that large populations could be screened for resistance. The feasibility of breeding for resistance was also proposed by Roach and Jackson (1992) since different clones in the Sugarcane World Collection based in Miami, Florida exhibited variation in *C. xyli* colonization. Similar results were demonstrated for commercial cultivars. These findings generated efforts to develop rapid methods of estimating *C. xyli* population levels. A sugarcane clone's RSD resistance was shown by Davis et al. (1988) to be inversely related to *C. xyli* population levels, while there was a positive correlation between bacterial population levels and the numbers of colonized vascular bundles (CVB). The tissue-blot enzyme immunoassay (TB-EIA) was selected as the method of choice (Davis, et al. 1994) because it permitted positive identification of infected plants and also provided a quantitative measure of infection as measured by the number of CVB. This system was used by Miller et al. (1995) to evaluate 30 plants in each of 10 crosses with 15 replications in a genetics test. This test demonstrated the feasibility of handling sufficiently large populations to permit progress in selecting for RSD resistance. A limiting factor with the TB-EIA procedure was the duration of time to evaluate large numbers of membranes containing the sap from the stalk samples. These had to be evaluated under the microscope, where individual CVB could be counted in each stalk core. Shine and Comstock (1993) applied a digital image analysis system to this problem so CVB numbers could be accurately determined by computer. However, a large-scale screening of clones in the regular breeding program faced another substantial problem. Seedcane in the program could not be inoculated since this would require heat treatment of all cultivars prior to commercial release.

Miller et al.(1995) reported heritability values for RSD resistance that ranged from 0.23, calculated by parent offspring regression, to 0.97, when calculated on a highly replicated plot mean basis. They also reported no strong correlation between CVB and yield components (Brix, stalk number, stalk diameter and stalk length)

The following methods and data were generated during our initial attempts to screen large numbers of selections for RSD resistance routinely.

METHODS AND MATERIALS

The breeding program at Canal Point is divided into five sections. The usual number of selections and plot sizes for each section, all with rows on 1.6 meter centers except for seedlings, are as follows: Seedling, 100,000 seedlings 0.3 meter apart in the row; Stage I, 8,000 to 12,000 selections, plot size is one 1.5 m row; Stage II, 800-1200 selections, plot size is two 4.6 m rows; Stage III, 131 selections, two 4.6 m rows replicated twice at four locations; and Stage IV, 10-12 selections, two 6 m rows with 8 replications at 10 locations. A goal of the RSD screening program was to start screening as early in the programs as possible.

The first experiments were conducted with selections moving from Stage II to Stage III. One stalk was cut into single bud seedpieces and inoculated by dipping cuttings in crude sap extracted from RSD-infected CP 53-1 [a clone known to develop high concentrations of *C. xyli*, as high as 5 x 10^8 cells per ml of crude sap (Davis, 1988.)]. Inoculated seedpieces were planted in flats in the greenhouse and subsequently transplanted to the field. Since this practice limited the number of clones that could be evaluated, the procedure was modified by inoculating single-bud seedpieces, and planting these directly in the field. This method worked in a preliminary test in October under ideal temperature and moisture conditions. However, the first screening of Stage II and Stage III clones in this manner failed presumably due to the late planting date (November-December) and less favorable weather conditions for germination (cool and dry). To overcome this problem, whole stalks were placed in the furrow. These were inoculated by dipping a cutting knife in crude sap of CP 53-1 (prior to each cut) and cutting stalks into three bud seedpieces prior to covering.

Stage III clones in the RSD screen had 4 replications in a complete randomized block design of a single stalk per replication. Five-stalk samples were collected from each of the 4 replications when the cane was 10-12 months, for a total of 20 stalks per clone. These were tested according to the procedure outlined by Comstock, et al. (1995, ISSCT XXII accepted for publication). Inoculation by cutting whole stalks with *C. xyli*-contaminated knives allowed for the evaluation of more clones, therefore selections from Stage I were also screened for their RSD reaction. All selected Stage I and Stage II clones that had sufficient seedcane were screened in a single unreplicated test. A single whole stalk was inoculated by cutting it into three-bud seedpieces using *C. xyli*-contaminated knives as described previously. Since this was a preliminary screen, only clones with >10 infected vascular bundles (some of our current commercial cultivars have levels this high when left untreated) were discarded.

Progeny from 100 crosses in 1992 and 99 crosses in 1993 were screened for RSD resistance. All data from both male and female parents were summarized by cross. Data were included in the analysis only if there were at least 10 progeny evaluated per parent. The percentage of progeny discarded was the number of clones with >10 CVB divided by the total number of clones in that cross. If the parent was used in more than one cross, the low and high number of CVB on a cross mean basis are presented. The average CVB for all progeny for each parent was calculated, and the CVB ratings of parents are shown, if known. A regression analysis was conducted by regressing average CVB of the offspring on the CVB of female and male parents. Heritability was defined by Becker (1968) as $h^2 = 2b$ for regression of offspring on parents.

RESULTS AND DISCUSSION

Results show increased variability in CVB detection when single-bud inoculation was changed to three-bud seedpiece inoculation. Variability has been reduced by eliminating clones with a single stalk count rating of >10 CVB. As more data are collected, CVB discard levels will probably decrease but to what level has not been determined. Also, the number of stalks tested was increased to 20 per clone (5 stalks from each of 4 replications) in later selection stages. Clones are tested repeatedly as they move through the selection cycle to eliminate any escapes. A clone's final rating will be an average from all tests.

Results of RSD screening (65% of the 586 clones) of the CP 92 Series clones advanced from Stage I to Stage II are presented in Table 1. From the 100 crosses with progeny in Stage II, there were 14 clones used as female parents that had at least 10 progeny screened. The most resistant parents (lowest CVB), based on their progeny, were US 90-1025, CP 84-1322, CP 85-1025 and Co 285. None of these parents produced progeny discarded for exceeding the CVB standard (CVB >10). Of these four clones, CVB counts were available only for CP 84-1322 and it was rated resistant (CVB = 0.02) (Davis et al. 1994). In this early stage, a culling level of 10

CVB was used because some current commercial varieties have CVB levels approaching 10 in diseased commercial fields where no RSD control measures are practiced. Two clones, US 88-1014 and CP 85-1758, had more than 20% of their progeny discarded for RSD susceptibility in these inoculated tests.

From the 99 crosses with progeny in Stage II, there were 15 female parents with at least 10 progeny screened in the CP 93 Series (in which 81% of the 615 clones were screened). Only one parent, CP 89-2319, had no progeny discarded because of high CVB levels (Table 2). This is one of the RSD resistant clones selected in the initial RSD genetics test (Miller, et al. 1995). There were four female parents (CP 76-1306, CP 86-1427, CP 86-1670 and CP 87-1733) that had > 20% of their progeny discarded. Over 2 years, 1201 clones were screened for RSD resistance, 586 progeny from 53 female clones in the CP 92 Series, and 615 progeny from 87 female clones in the CP 93 Series (data not shown).

Data for male parents of the CP 92 and CP 93 Series are shown in Tables 3 and 4, respectively. In the CP 92 Series, 36 clones were used as male parents, of which 12 males and 3 polycrosses had at least 10 progeny screened. In the CP 93 Series, there were 57 clones used as male parents and 17 male parents and 1 polycross had at least 10 progeny screened. In contrast to the female-parent data, all male parents had at least one progeny discarded for exceeding the CVB threshold. Two clones, CP 80-1743 and SP 70-1143, in the CP 92 Series, and one polycross, 89P4, had greater than 20% of their progeny discarded. In the CP 93 Series, four male parents (AKOKI-22, CP 85-1491, CP 88-2045 and CP 89-2178) had greater than 20% of their progeny discarded for exceeding the CVB cut off level.

The total number of clones screened for resistance to RSD represented 65 and 81 percent of the CP 92 and CP 93 Series populations, respectively. The overall rate that clones were discarded for RSD susceptibility in the CP 92 Series was 12.1%, compared to 13.3% in the CP 93 Series. This difference could be a reflection of the specific parents used in crosses or it could reflect year to year variation in infection efficiency. However, the numbers are sufficiently similar to signify that progress for selection for RSD resistance should be possible under the present system.

Heritability estimates the probability that a particular trait will be transmitted from one generation to the next. Heritability can be measured by regressing the average value for the progeny on the mean value of the parents. Although heritability values are usually calculated from replicated test data, CVB data were not replicated because of limited amount of seedcane. Also, ratings on parent clones come from different tests. With these limitations, the calculated heritability of RSD resistance was $h^2 = 0.52$ based on data from 11 female parents and 444 progeny. When 17 male parents and 468 progeny were used, the heritability was $h^2 = 0.26$. These two values represent the range of h^2 estimates obtained by Miller et al. (1995). Although their data showed no difference in effect when measured from female and male sources, no resistant clone was used as a female in their study. More data are needed to determine if these heritability differences are an example of the normal range in variation, or if in fact, there is some maternal effect on inheritance of RSD resistance. This could also simply reflect the random choice of parents used in these CP series, since parental selection was not made in an effort to select for RSD resistance in either CP series.

The 55 parents selected for use in the RSD breeding project in the 1995 crossing season (Table 5) represent different degrees of CVB rating reliability. The data from the CP 91 series and the US 94 series are based on a single replication and only 3 samples. Ratings of clones prior to the CP 91 series have been evaluated with larger number of replications and may have been in more that one test, so the CVB ratings on them should be more reliable. Clones selected for use as parents in the RSD breeding project were required to meet higher standards (an average CVB rating of < 2 and no individual stalk CVB rating of > 5) than those in the regular breeding program. Of the 55 clones selected for use as parents in the RSD resistance breeding project, 26 of them are also in the regular breeding program. This high percentage should facilitate selection for adapted RSD resistant commercial cultivars.

The best estimate of the ability of a parent (either as a female or male) to transmit RSD resistance may be that provided by the average CVB rating for all progenies (Tables 1, 2, 3, and 4). In the CP 92 series, four clones had a progeny mean CVB rating of < 2.0, while in the CP 93 series, no progeny had a CVB rating of < 2.0 and only one clone a rating of <3.0 . In both series, CP 84-1591 was represented by the most progeny with ratings of 3.49 and 3.95 in the CP 92 and 93 series, respectively (Tables 3 & 4). Average CVB-progeny ratings for CP 70-1133 and CP 72-2086 were both slightly higher in the 1993 series than those in the 1992 series. However, the average CVB ratings for CP 80-1827 were much lower in the 1993 series. This was probably due to the low number of progeny evaluated in the 1993 series and the fact that it was crossed with a resistant parent in one of two crosses.

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Table 1. Female parents, number of progeny rated, percent RSD susceptibility (CVB>10), CVB range across crosses, average CVB rating of progeny and parents used in the 1992 CP series at Canal Point, Fl.

Variety	Total progeny	% with CVB>10	CVB Range Min	CVB Range Max	Average CVB rating Progeny[1]	Average CVB rating Parent
Co 285	39	0.0	0.0	1.9	1.84	
CP 80-1827	45	13.3	1.1	8.7	3.61	
CP 81-1425	40	12.5	3.9	29.3	4.55	
CP 81-2149	18	0.0	2.8	4.0	2.98	
CP 82-2043	34	11.8	3.0	10.3	3.27	
CP 83-1770	11	18.2	3.8	-	3.79	
CP 84-1322	11	0.0	0.4	2.9	1.54	0.02
CP 85-1025	14	0.0	1.7	-	1.71	
CP 84-1591	117	11.3	0.0	5.5	3.49	7.3
CP 85-1758	31	22.5	0.0	10.3	5.12	
US 88-1014	33	27.3	2.3	11.7	7.84	
US 88-1016	16	6.3	2.7	5.5	3.48	
US 90-1025	12	0.0	0.0	2.4	1.05	
CP 70-1133	14	0.0	1.7	2.4	2.31	6.8
Total/Average	435	10.8				

[1] Average CVB rating for progeny was calculated as the average for each clone summed and divided by the number of clones in the progeny and/or progenies.

Table 2. Female parents, number of progeny rated, percent RSD susceptibility (CVB>10), CVB range across crosses, and average CVB rating of progeny and parents used in the 1993 CP series at Canal Point, Florida.

Cultivar	Total progeny	% with CVB>10	CVB range Min	CVB range Max	Average CVB rating Progeny[1]	Average CVB rating Parent
CP 70-1133	39	0.0	2.6	0.7	4.71	6.8
CP 76-1306	11	45.5	8.0	-	8.00	
CP 78-1610	18	5.3	2.5	5.3	3.39	
CP 81-1238	39	12.8	0.0	22.3	4.10	2.5
CP 84-1185	35	17.1	0.7	11.1	4.38	0.1
CP 84-1591	123	9.2	0.0	8.4	3.95	7.3
CP 86-1331	19	10.5	3.3	5.3	3.52	
CP 86-1427	32	21.8	5.2	9.3	5.48	10.2
CP 86-1665	10	11.3	3.6	-	3.60	
CP 86-1670	44	25.0	5.7	7.0	5.85	
CP 87-1733	12	41.7	5.0	20.7	7.80	17.3
CP 89-2066	17	17.6	1.0	8.9	5.07	
CP 89-2319	12	0.0	0.0	0.0	2.78	1.9
CP 89-2372	10	10.0	5.8	12.0.	3.50	5.9
Total/Average	421	14.3				

[1] Average CVB rating for the progeny was calculated as the average for each clone summed and divided by the number of clones in the progeny and/or progenies.

Table 3. Male parents, number of progeny rated, percent RSD susceptibility (CVB>10), CVB range across crosses and average CVB rating of progeny and parents used in the 1992 CP series at Canal Point, Florida.

Variety	Total Progeny	%with CVB>10	CVB range Min	CVB range Max	Average CVB rating Progeny[1]	Average CVB rating Parent
88P 11	48	8.3	2.9	3.9	3.72	
89P 4	11	27.3	3.5	10.3	4.09	
89P 5	12	16.6	0.0	19.0	4.02	
CP 56-59	24	8.3	0.3	6.3	3.19	
CP 70-1133	47	10.6	0.0	14.3	3.12	6.8
CP 72-2086	66	1.5	0.0	4.4	2.23	1.9
CP 80-1743	24	25.0	5.0	9.9	6.61	1.9
CP 80-1827	14	14.3	2.9	7.9	6.11	7.7
CP 81-1135	25	16.0	0.0	9.9	4.83	
CP 81-1425	38	15.8	0.3	15.7	5.23	
CP 82-1505	12	8.3	2.0	3.0	2.44	
CP 84-1322	48	12.5	3.4	3.9	3.58	0.02
CP 84-1591	71	4.3	0.0	8.8	3.71	7.3
CP 85-1845	94	5.3	0.8	5.5	2.46	
SP 70-1143	34	26.5	1.3	19.2	5.50	
Total/Average	497	11.3				

[1] Average CVB rating for the progeny was calculated as the average for each clone summed and divided by the number of clones in the progeny and/or progenies.

Table 4. Male parents, number of progeny rated, percent RSD susceptbility (CVB>10), CVB range across crosses, and average CVB rating of progeny and parents used in the 1993 CP series at Canal Point, Florida.

Variety	Total progeny	%with CVB>10	CVB range		Average CVB rating	
			Min	Max	Progeny	Parent
90P 19	28	14.3	0.0	4.6	3.87	
AKOKI 22	11	27.3	0.0	12.3	3.35	
CL 73-239	45	6.6	0.0	5.2	3.34	0.03
CP 70-1133	26	15.4	0.4	13.7	3.40	6.8
CP 72-1210	40	10.0	0.4	7.1	4.35	9.6
CP 72-2086	37	5.4	1.2	4.0	3.32	1.9
CP 80-1827	11	18.2	0.3	14.0	3.37	7.7
CP 81-1238	11	9.1	0.7	3.0	1.81	2.5
CP 85-1207	11	9.1	1.4	5.7	2.18	
CP 85-1491	12	25.0	0.3	9.5	5.42	7.3
CP 86-1206	34	8.8	0.0	7.0	3.15	
CP 86-1664	46	19.6	0.0	11.1	6.11	14.5
CP 86-1705	16	12.5	3.6	8.3	4.18	
CP 88-2045	23	26.1	1.7	28.3	6.31	
CP 89-2178	25	24.0	0.0	8.0	5.13	
CP 89-2335	15	13.3	0.0	21.7	3.59	
LCP 82-89	18	5.3	0.0	5.8	4.25	14.0
SP 71-3501	77	16.9	0.0	15.0	5.29	
Total/Average	487	14.2				

[1] Average CVB rating for the progeny was calculated as the average for each clone summed and divided by the number of clones in the progeny and/or progenies.

Table 5. Fifty-five clones selected as parents in the RSD breeding program during the 1995-96 crossing season at Canal Point, Florida.

Variety	CVB	Parentage	Variety	CVB	Parentage
CP72-2086[1]	1.9	CP62-374 X CP63-588	CP91-1115	1.5	CP83-1770 X CP83-1969
CL73-239[1]	0.0	CP78-2114 X CP78-1610	CP91-1498	1.6	CP83-1770 X CP80-1827
CP81-1302[1]	0.0	CL65-433 X CL66-636	CP91-1238[1]	1.0	CP70-1133 X 88P7
CP73-1547[1]	0.8	CP66-1043 X CP56-63	CP91-1284	1.3	CP81-1425 X 88P7
CP78-1628[1]	0.8	CP72-2079 X CP71-1086	CP91-1549	1.6	CP86-1791 X CP82-2043
CP82-1172[1]	1.9	CP75-1091 X CP75-1283	CP91-1560[1]	1.0	CP86-1791 X CP82-2043
CP82-1592[1]	0.2	CP72-1210 X CP70-1133	CP91-1577	1.6	CP86-1791 X CP82-2043
CP85-1308[1]	0.0	R 567 X CP 74-2013	CP91-1609	1.6	CP83-1770 X CP82-1505
CP88-1540[1]	0.4	CP81-1238 X CP78-1610	CP91-1794	0.0	CP82-1505 X CP80-1743
CP88-1561[1]	0.6	CP81-1238 X CP80-1827	CP91-1883	0.7	CP80-1827 X CP84-1322
CP88-1762[1]	0.7	CP80-1743 X 85P6	CP91-1921	0.0	CP86-1791 X CP81-2149
CP88-1912[1]	0.5	CP78-2114 X 85P6	CP91-1924[1]	1.7	CP86-1791 X CP81-2149
CP89-1268[1]	1.2	CP78-2114 X CP78-1610	CP91-1927	0.0	CP86-1791 X CP81-2149
CP89-1632[1]	0.1	CP73-1547 X CP81-1254	CP91-1980[1]	0.2	CP62-374 X CP84-1322
CP89-1643[1]	1.3	CP73-1547 X CP81-1254	CP91-2105	1.7	CP86-1791 X CP81-2149
CP89-1945[1]	0.8	CP72-2086 X CP78-1610	CP91-2164	0.3	CP80-1827 X CP81-2149
CP89-2377[1]	0.0	UNKNOWN	CP91-2179	1.5	CP73-1547 X CP81-2149
CP90-1129	0.6	CP72-1210 X 87P4	US94-1003	0.0	CP82-1592 X CP89-2335
CP90-1151[1]	0.5	CP78-1247 X 87P4	US94-1010	0.0	CP89-2365 X CP89-2335
CP90-1204[1]	1.9	CP82-2043 X CP78-1610	US94-1012	0.0	CP89-2365 X CP89-2335
CP90-1243	0.0	CP80-1827 X CP82-1172	US94-1014	0.0	CP89-2373 X CP89-2335
CP90-1371	0.0	CP78-1610 X CP82-1172	US94-1015	0.0	CP89-2373 X CP89-2335
CP90-1533	0.0	57NG-252 X 88P6	US94-1016	0.0	CP89-2373 X CP89-2335
CP90-1535[1]	0.1	CP81-1425 X 88P7	US94-1020	0.0	CP89-2373 X CP89-2335
CP90-1549[1]	0.6	CP82-1549 X CP84-1322	US94-1024	0.0	CP89-2365 X CP89-2335
CP90-1622	0.7	CP83-1770 X CP84-1322	US94-1025	0.0	CP89-2365 X CP89-2335
CP90-1741	0.0	CP78-1247 X CP81-1425	US94-1027	0.0	CP89-2365 X CP89-2335
CP91-1062[1]	1.2	CP83-1281 X 88P9			

[1] Also in the regular variety selection program.

MECHANICAL HARVESTING EFFECTS ON SUGARCANE CULTIVARS GROWN ON ORGANIC SOILS

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ABSTRACT

For much of the Florida sugarcane industry's history, manual laborers harvested about 75% of the crop. Now, a rapid change is complete and 100% of Florida's milled sugarcane (a complex hybrid of *Saccharum* spp.) is harvested by machines. The sugarcane cultivar development program at Canal Point (CP) now routinely subjects promising experimental clones to commercial mechanical harvesters. However, more information was needed on responses to mechanical harvesting of many already released sugarcane cultivars as 75% of Florida's harvest rapidly changed from manual to mechanized harvesting. The purpose of this study was to compare, when subjected to mechanized harvesting, the plant-cane through second-ratoon yields of established and promising sugarcane cultivars in Florida. Three experiments were planted in the fall of 1991, one on land previously subjected to a summer flooded fallow period, and two on land subjected to a successive sugarcane rotation. A major concern in Florida is that root damage during a mechanical harvest will reduce yields of subsequent ratoons. Therefore, cultivars whose cane-tonnage yields were highest relative to other cultivars in the ratoon crops were categorized as well adapted to mechanical harvesting. Significant crop (plant-cane, first-ratoon, and second-ratoon crops) x cultivar interactions in two experiments suggested that mechanical harvesters did not affect all cultivars similarly. Among nine cultivars that were planted in all three experiments, CP 80-1827 had the highest yields. Four cultivars that yielded similarly to each other, but lower than CP 80-1827, were CP 70-1133, CP 72-2086, CP 85-1308, and CP 85-1382. CP 80-1743 and CP 84-1198 were not planted in each of the three experiments but yielded well where planted. Except for an extreme negative case with CP 82-1172, cultivar characteristics such as ability to remain upright or to maintain straight stalks after lodging were not good predictors of which cultivars would produce high ratoon yields following mechanical harvests.

INTRODUCTION

For much of the Florida sugarcane industry's history, manual laborers harvested about 75% of the crop. However, improvements in mechanical harvesters, increased labor costs, and increased legal costs associated with the laborers accelerated a shift to mechanical harvesting in 1988. Eiland and Miller (1992) reported that by 1991, 40% of Florida's sugarcane was harvested mechanically. Now, 100% of the cane sent to mills in Florida is harvested by machines.

The 1993-94 harvest season was the first season that the Canal Point (CP) sugarcane cultivar development program subjected promising experimental clones to mechanical harvesting in the final stage of its program (Glaz et al. 1994). The CP 89 series is the first series to be mechanically harvested from the plant-cane through the second-ratoon crop of the final stage of the CP program. Late 1996 is the soonest any CP 89 clone will be commercially released. As the rapid switch to mechanical harvesting occurred, growers desired more information about how cultivars would yield after being harvested mechanically.

A major concern about mechanical harvesting was potential variability among cultivars to yield well in ratoon crops. Because many of the organic soils in Florida are not firm, it was feared that mechanical harvesters would often cause sugarcane stool death by injuring roots as they harvested stalks. Another concern was that harvesters would remove entire stools from the ground. Both the root injuries and loss of stools would reduce subsequent ratoon yields. Due to differences in growth habits and root systems, not all cultivars react similarly to mechanical harvesters (Eiland and Miller, 1992). The purpose of this study was to compare, when subjected to mechanized harvesting, the plant-cane through second-ratoon yields of established and promising sugarcane cultivars in Florida.

MATERIALS AND METHODS

Three sugarcane experiments were planted on organic soils, Histosols, in Florida in 1991. One experiment was planted at New Hope Sugar Company (New Hope) near the Osceola mill and two were planted at Okeelanta Corporation (Okeelanta) near the Okeelanta mill. The New Hope experiment and one Okeelanta experiment (Okeelanta successive) were planted in successive sugarcane rotations. The field of the other Okeelanta experiment had previously been fallow flooded (Okeelanta fallow). The New Hope experiment was planted on 29 Nov. 1991; the Okeelanta fallow experiment on 31 Oct. 1991; and the Okeelanta successive experiment on 27 Dec. 1991. The soil at New Hope was a Pahokee muck and the soils in both experiments at Okeelanta were Lauderhill mucks. Both Pahokee and Lauderhill mucks are euic, hyperthermic Lithic Medisaprists.

Each experiment was a randomized complete-block design with four replications. The treatments in each experiment were cultivars. The twelve cultivars planted in the New Hope experiment are listed in Table 1. The nineteen cultivars and one unreleased clone, CP 82-2043, planted in the Okeelanta fallow experiment are listed in Tables 2-4. The sixteen cultivars planted in the successive experiment at Okeelanta are listed in Tables 5-7.

All plots were planted with two lines of seed cane per furrow. Each plot was 15.2 m long and 6.1 m wide (0.0093 ha). The distance between rows was 1.5 m, and 1.5 m alleys separated the front and back ends of plots. The margins of the experiments were protected with at least one border row of sugarcane on each side and 1.5 m of sugarcane in the front and back. Each experiment was 10 rows wide. These 10 rows were comprised of the two border rows, one on each side of the experiment, and two plots, each four rows wide. No extra space or border rows separated adjacent plots. All plots were subjected to normal commercial cultivation and harvesting procedures and equipment used by New Hope and Okeelanta.

Yield information from the New Hope experiment was obtained from the plant-cane and second-ratoon crops. Yield information was obtained for the complete plant-cane through second-ratoon cycle from both Okeelanta experiments. Total millable stalks were counted and sampled in all plant-cane through second-ratoon plots before entire experiments were harvested by commercial mechanical harvesters. Two samples of 10 unburned, mature stalks were collected from each plot. One sample was cut from an outside plot row and one sample was cut from an inside plot row. From these samples, stalk weights and theoretical sugar concentrations were estimated. Theoretical sugar concentration, measured as kg of sugar Mg^{-1} of cane, was calculated according to procedures described by Legendre (1992).

At the New Hope experiment, stalks were counted in plant cane on 27-28 Jul 1992, and in second ratoon on 18 Jul 1994. At the Okeelanta fallow experiment, stalks were counted in plant cane on 5-7 and 11 Aug 1992, in first ratoon on 20 Sep 1993, and in second ratoon on 18 Jul 1994. At the Okeelanta successive experiment, stalks were counted in plant cane on 5 Jul 1992, in first ratoon on 16 Sep 1993, and in second ratoon on 11 Aug 1994. All plant-cane counts took place greater than 180 days after planting and all ratoon counts took place greater than 180 days after the previous harvest. According to Eiland and Dean (1981), populations probably had already peaked, declined, and levelled off by this time. According to Glaz and Kang (1986), similar differences among cultivars could be determined from June or August stalk counts. Therefore, differences in date of stalk counting were not expected to influence relative yields among cultivars.

At the New Hope experiment, stalks were sampled from plant cane on 3 Dec 1992, and from second ratoon on 27 Oct 1994. At the Okeelanta fallow experiment , stalks were sampled from plant cane on 27 Oct 1992, from first ratoon on 13 Jan 1994, and from second ratoon on 14 Nov 1994. At the Okeelanta successive experiment , stalks were sampled from plant cane on 27 Oct 1992, from first ratoon on 1 Nov 1993, and from second ratoon on 11 Dec 1994.

Cane yield was calculated as the product of total stalk number by mean stalk weight and is reported as Mg cane ha^{-1}. Sugar yield was calculated as the product of cane yield by sugar concentration and is reported as Mg sugar ha^{-1}.

Data for sugar concentration, cane yield, and sugar yield from each experiment were subjected to analysis of variance for a randomized complete-block design for one location combined across crop years. Significant differences among cultivar means were sought at $P = 0.1$ using the unprotected LSD. The data of the nine cultivars common to all three experiments were analyzed as a randomized complete-block design combined across eight locations. The "locations" were each harvest at each experiment. Thus, two locations came from the plant-cane and second-ratoon harvests at New Hope and six locations came from Okeelanta, the plant-cane through second-ratoon harvests of both the fallow and successive experiments. Stability-safety indices for these eight "locations" were calculated using Shukla's stability variance as described by Eskridge (1990).

RESULTS AND DISCUSSION

New Hope, Planted immediately following Sugarcane (Successive)

The results of the plant-cane and second-ratoon crops of the experiment planted at New Hope are listed in Table 1. The F values for crop x cultivar interaction for cane yield and sugar yield were not significant (data not shown). Thus, we assumed that the relative differences in yields among cultivars were similar in plant-cane and second-ratoon. Therefore, only the two-crop means are reported in Table 1.

CP 80-1827 yielded significantly more sugar yield than any cultivar except CP 70-1133 and significantly more cane yield than any cultivar except CP 81-1254 and CP 70-1133. There were no significant sugar yield differences among CP 70-1133, CP 81-1254, CP 85-1382, CP 78-1628, CP 72-2086, CP 85-1308, and CL 72-321. CP 85-1308 yielded significantly more sugar concentration than any cultivar except CL 72-321 and CL 61-620. After CP 85-1308, CL 72-321 yielded significantly more sugar concentration than all cultivars except CL 61-620, CP 85-1382, and CL 69-886.

Okeelanta, Planted following Flooded Fallow (Okeelanta Fallow)

The results of the Okeelanta fallow experiment were more complex because there were significant crop x cultivar interactions for all three yield characteristics, sugar concentration, cane yield, and sugar yield (data not shown). Probably date of harvest rather than mechanical harvesting was the major cause of the significant sugar concentration interactions. However, mechanical harvesting probably accounted for a substantial portion of the significant crop x cultivar interactions for cane yield. Interaction effects on sugar yield were probably equally split among factors that influenced interactions on cane yield and sugar concentration. Results of the plant-cane through second-ratoon harvests for the 19 sugarcane cultivars and one experimental clone are in Table 2 for sugar concentration, Table 3 for cane yield, and Table 4 for sugar yield.

The five cultivars with the most sugar yield were CP 80-1827, CP 82-1172, CP 80-1743, CP 84-1198, and CP 85-1308 (Table 4). All five of these cultivars, along with the unreleased clone CP 82-2043, ranked among the six clones that yielded the most cane yield (Table 3). Three of these cultivars, CP 80-1827, CP 84-1198, and CP 80-1743 along with CL 61-620, CL 73-239, and CP 81-1254 were the six cultivars that yielded the most sugar concentration (Table 2).

CP 82-1172 did not maintain consistently high yields from one harvest to the next. As plant cane, CP 82-1172 yielded significantly more Mg cane ha^{-1} than 16 of the other 19 clones (Table 3). As first ratoon, CP 82-1172 yielded significantly more Mg cane ha^{-1} than all other clones. Thus, it withstood the plant-cane mechanical harvest well. However, as second ratoon, seven cultivars yielded significantly more Mg cane ha^{-1} than CP 82-1172. Particularly for growers who would hope to extend harvests to third ratoon, this sharp decline in second ratoon raises doubts about the adaptability of CP 82-1172 to mechanical harvesting. Root damage caused by harvesting the extremely unwieldy growth habit of CP 82-1172 may have contributed to its low ratoon yields.

Like CP 82-1172, CP 80-1827 had very high cane yields in the plant-cane and first-ratoon crops. In plant cane, CP 80-1827 yielded significantly more Mg cane ha^{-1} than any other clone except CP 82-1172. However, in first ratoon, the cane yield of CP 80-1827 was significantly higher than only six other clones. Unlike CP 82-1172, compared relatively to the other clones, CP 80-1827 declined in cane production from the plant-cane to the first-ratoon crop. In second ratoon, three other cultivars yielded significantly more cane yield than CP 80-1827. Thus, CP 80-1827 continued a relative decline from first to second ratoon, but its decline at this phase was not as severe as that of CP 82-1172.

No other cultivar yielded significantly more sugar concentration than CP 80-1827 from the plant-cane through the second-ratoon crops (Table 2). Also, CP 80-1827 yielded significantly more sugar concentration than 14 other clones for the three-crop cycle, and significantly more than 9 or 10 other clones in each annual harvest. For the three-crop cycle, CP 80-1827 was a preferable mechanical harvesting candidate to CP 82-1172 because its decline from first ratoon to second ratoon was not as steep as that of CP 82-1172 and because of its higher sugar concentration. CP 80-1827 became the most widely grown cultivar in Florida in the 1995-96 harvest season (Glaz, 1995).

As plant cane, five cultivars had significantly greater cane yields than CP 80-1743 (Table 3). However, in the two ratoon crops, no other cultivar yielded significantly more Mg cane ha^{-1}

than CP 80-1743 except for CP 82-1172 in first ratoon. As second ratoon, CP 80-1743 yielded significantly more Mg cane ha^{-1} than 17 of the remaining 19 clones. These data suggest that CP 80-1743 was well adapted to mechanical harvesting, and with a high-yielding initial crop, CP 80-1743 would have been the best suited to a three-harvest mechanical harvesting cycle. CP 80-1743 yielded high kg sugar Mg^{-1} cane over the three-crop cycle, but its sugar concentration was not as consistently high as that of CP 80-1827 (Table 2). In plant cane, CP 80-1743 had a low sugar concentration, in first ratoon its sugar concentration was significantly more than 16 of the remaining 19 clones, and in second ratoon its sugar concentration was significantly more than seven other clones.

CP 85-1308 and CP 84-1198 were both similar to, but not as extreme as CP 80-1743. Their relative cane yield rankings were higher in the ratoons than in the plant-cane crop. However, CP 85-1308 nearly yielded significantly more cane yield than CP 80-1743 in the plant-cane crop (Table 3). As first ratoon, only CP 82-1172 yielded significantly more Mg cane ha^{-1} than CP 85-1308 and CP 84-1198, and as second ratoon, CP 85-1308 and CP 84-1198 were the only two cultivars that did not yield significantly less Mg cane ha^{-1} than CP 80-1743 (Table 3). In each of the three harvests, CP 84-1198 had significantly greater sugar concentrations than CP 85-1308 (Table 2).

Okeelanta, Planted immediately following Sugarcane (Okeelanta Successive)

Results of the Okeelanta successive experiment are in Table 5 for sugar concentration, Table 6 for cane yield, and Table 7 for sugar yield. Before planting this experiment, there were commercial equipment shortages which resulted in less than desirable land preparation. This probably caused the observed low rates of emergence and tillering (data not shown) and the low plant-cane yields shown in tables 6 and 7.

Relative results among some cultivars were similar to those of the Okeelanta fallow experiment. As in the Okeelanta fallow experiment, significant crop x cultivar interactions existed for sugar concentration, cane yield, and sugar yield (data not shown). The five cultivars with the most sugar yield were CP 80-1743, CP 78-1628, CP 80-1827, CP 82-1592, and CP 72-2086 (Table 7). CP 80-1743 had a significantly greater sugar concentration than any of these five cultivars and significantly more than all cultivars except CP 84-1198 (Table 5). Four of these cultivars, CP 78-1628, CP 82-1592, CP 80-1827, and CP 80-1743 had the highest cane yields (Table 6).

As in the Okeelanta fallow experiment, CP 80-1743 had a low plant-cane cane yield (Table 6). Nine other cultivars yielded significantly more Mg cane ha^{-1} than CP 80-1743 in the plant-cane crop. However, in both ratoons, no other cultivar yielded significantly more Mg cane ha^{-1} than CP 80-1743, and six cultivars in first ratoon and 12 cultivars in second ratoon yielded significantly less Mg cane ha^{-1} than CP 80-1743. These high ratoon yields suggest that CP 80-1743 was similarly well adapted to mechanical harvesting in both the fallow and successive experiments at Okeelanta. A low cane yield for CP 80-1743 in plant cane with high cane yields in the ratoon crops was also reported by Eiland and Miller (1992). However, in that experiment preferential damage by rats to CP 80-1743 was identified as the reason for the low plant-cane cane yield of CP 80-1743. In the present experiment, no reason was identified.

The plant-cane through second-ratoon cane yields of CP 78-1628 showed that this cultivar was well adapted to mechanical harvesting. In the plant-cane crop, CP 78-1628 yielded significantly more Mg cane ha^{-1} than 14 of the remaining 15 cultivars (Table 6). Although its cane yield was not as dominantly high in the ratoon crops, no cultivar in either ratoon yielded significantly more Mg cane ha^{-1} than CP 78-1628. In first ratoon, CP 78-1628 yielded significantly more Mg cane ha^{-1} than six other cultivars, and in second ratoon, CP 78-1628 yielded significantly more Mg cane ha^{-1} than five other cultivars.

CP 80-1827 yielded significantly more Mg cane ha^{-1} than six other cultivars in the plant-cane crop; CP 78-1628 was the only cultivar that yielded significantly more Mg cane ha^{-1} than CP 80-1827 in the plant-cane crop. The cane yields of CP 80-1827 in the first- and second-ratoon crops were similar to those of CP 78-1628. These consistent relative cane yields of CP 80-1827 throughout the three-crop cycle indicate that CP 80-1827 yields were not affected by mechanical harvesting,.

CP 82-1592 and CP 72-2086 did not have outstanding yields in the Okeelanta fallow experiment (Tables 2-4). Of these two cultivars, only CP 72-2086 was planted at New Hope, where its yields were respectable (Table 1). In the Okeelanta successive experiment, the cane yields of CP 82-1592 and CP 80-1827 were similar in the plant-cane and first-ratoon crops (Table 6). However, in the second-ratoon crop, CP 82-1592 yielded significantly more Mg cane ha^{-1} than 10 other cultivars. This relative improvement in cane yield in the last harvest in the cycle is an indication that CP 82-1592 was well adapted to mechanical harvesting. The major drawback of CP 82-1592 was its low sugar concentration; 10 other cultivars had significantly greater sugar concentrations than CP 82-1592 (Table 5).

CP 72-2086 had cane yields similar to those of CP 82-1592 in the plant-cane and first-ratoon crops. In the second-ratoon crop, CP 82-1592, along with CP 80-1743, yielded significantly more Mg cane ha^{-1} than CP 72-2086 (Table 6). However, since CP 72-2086 also yielded significantly more Mg cane ha^{-1} than three other cultivars in second ratoon, CP 72-2086 can be classified as moderately well adapted to mechanical harvesting.

In the plant-cane crop, CP 70-1133 yielded significantly more Mg cane ha^{-1} than seven other cultivars. Also, CP 70-1133 was the only cultivar in the plant-cane crop that did not yield significantly less Mg cane ha^{-1} than CP 78-1628 (Table 6). The first-ratoon cane yield of CP 70-1133, relative to the cane yields of the other cultivars, remained similar. However, in the second-ratoon crop, CP 82-1592 and CP 80-1743 yielded significantly more Mg cane ha^{-1} than CP 70-1133 while only two other cultivars yielded significantly less Mg cane ha^{-1} than CP 70-1133 (Table 6). This slight relative decline in cane yield in the second-ratoon crop caused CP 70-1133 to be classified as less adaptable to mechanical harvesting than CP 72-2086.

Combined Analysis for Common Cultivars

Nine cultivars were planted in all three experiments (Table 8). Of these cultivars, CP 80-1827 yielded significantly more Mg cane and sugar ha^{-1} than any other cultivar for data combined across all harvests. CP 80-1827 also yielded significantly more sugar concentration than six of the eight remaining cultivars. Eiland and Miller (1992) also reported high yields for CP 80-1827. CP 70-1133, CP 72-2086, CP 85-1308, and CP 85-1382 all yielded less Mg sugar ha^{-1} than CP 80-1827. However, these four cultivars all had similarly high sugar concentrations, cane yields, and sugar yields (Tables 5-7).

The stability-safety index measures the ability of a cultivar to have both high and stable yields across environments (Eskridge, 1990). In this case, each harvest at each location was treated as one environment. Therefore, a high stability-safety index indicates a cultivar had consistently high yields for all harvests in each of the three experiments[1]. Thus, the stability-safety index can be used as a tool to measure a cultivar's adaptation to mechanical harvesting. A low stability-safety index could mean that a cultivar was poorly adapted to mechanical harvesting because of plant-cane yields relatively higher compared to other cultivars and ratoon yields lower than those of others. However, a low stability-safety index could also be due to relatively low plant-cane yields and then relatively higher ratoon yields. If one could improve the plant-cane yields of such a cultivar, then it would be well adapted to mechanical harvesting.

The cultivars that had high yields also had high stability-safety indices. CP 80-1827 had the highest stability-safety indices for cane and sugar yields, and the index of CP 80-1827 for sugar concentration ranked number two behind that of CL 61-620. Two stability values of note are those of cane yield for CL 61-620 and CP 81-1254. Both of these values would rank these cultivars lower than they would have from only the yield rankings. This indicates that these cultivars had relatively high cane yields for some harvests and relatively low for others. For CL 61-620, these low stability-safety indices emphasized its potentially high adaptation to mechanical harvesting. After relatively low cane yields in all plant-cane harvests, CL 61-620 had relatively high cane yields in ratoon harvests. CP 81-1254 was poorly adapted to mechanical harvest. Its plant-cane cane yields were relatively high whereas its ratoon cane yields were lower.

Most sugarcane farmers in Florida probably do not expect that CP 80-1827 will commercially yield consistently high sugar concentrations as it did in these experiments. A possible explanation for this discrepancy is that CP 80-1827 has a reputation of being more susceptible to the sugarcane borer, *Diatraea saccharalis* (F.), than most sugarcane cultivars in Florida. As reported by Ulloa et al. (1982), one bored internode per stalk causes a reduction in sugar concentration of 2.8 kg Mg^{-1} of cane. Since borer pressure was low in these experiments, the levels of borer infestations on CP 80-1827 were probably lower than those found in many commercial fields of CP 80-1827, and therefore, the sugar concentrations reported here were higher than those generally associated with CP 80-1827.

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[1] When comparing two stability-safety indices < 0, the lower the absolute value, the greater the stability-safety index. Any stability-safety index > 0 is greater than any stability-safety index < 0.

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Table 1. Mean of plant-cane and second-ratoon sugar and tonnage yields of 12 cultivars planted successively after sugarcane at New Hope and harvested mechanically.

Cultivar	Cane yield	Sugar concentration	Sugar yield
	Mg ha^{-1}	kg sugar Mg^{-1}	Mg ha^{-1}
CP 80-1827	122.0	107.7	13.34
CP 70-1133	110.5	109.1	12.32
CP 81-1254	113.8	103.6	11.92
CP 85-1382	104.0	110.0	11.70
CP 78-1628	105.4	109.8	11.69
CP 72-2086	102.2	108.3	11.22
CP 85-1308	94.0	115.0	11.18
CL 72-321	94.0	112.8	10.98
CL 61-620	93.5	112.1	10.68
CP 70-1527	97.8	104.6	10.36
CL 69-886	87.4	111.8	10.21
CP 78-2114	89.7	108.5	9.82
Mean	101.2	109.4	11.07
LSD (0.1)	12.6	2.9	1.38

Table 2. Plant-cane through second-ratoon sugar concentrations, measured as kg sugar Mg^{-1} cane, of 20 cultivars planted following a flooded fallow period at Okeelanta Corp. and harvested mechanically.

Clone	Plant cane	First ratoon	Second ratoon	Mean
	--------kg sugar Mg^{-1} cane--------			
CP 80-1827	101.2	122.6	125.4	116.4
CP 84-1198	101.3	119.5	126.6	115.8
CL 61-620	100.2	118.2	127.8	115.4
CP 80-1743	92.8	124.5	125.1	114.1
CL 73-239	106.4	114.3	121.3	114.0
CP 81-1254	102.3	118.7	116.7	112.6
CP 72-2086	96.4	120.8	116.9	111.4
CP 73-1547	88.8	118.7	123.9	110.5
CP 82-1172	89.9	118.1	122.5	110.2
CP 72-1210	93.6	117.8	118.4	109.9
CP 70-1133	89.9	114.1	120.3	108.1
CP 85-1491	98.7	110.3	115.0	108.0
CP 85-1382	94.6	113.7	115.8	108.0
CP 85-1308	88.8	112.4	117.6	106.3
CP 82-1592	85.2	109.7	121.8	105.6
CP 70-1527	91.8	113.1	110.1	105.0
CP 85-1432	88.4	112.5	111.7	104.2
CP 81-1302	90.2	105.3	113.1	102.9
CP 80-2043	77.4	118.3	112.2	102.6
CP 78-2114	79.3	111.9	114.3	101.8
Mean	92.8	115.2	118.8	109.0
LSD (0.1)	9.9	5.5	8.4	4.7

Table 3. Plant-cane through second-ratoon cane tonnages, measured as Mg ha^{-1}, of 20 cultivars planted following a flooded fallow period at Okeelanta Corp. and harvested mechanically.

Clone	Plant cane	First ratoon	Second ratoon	Mean
	---------------------	Mg ha^{-1}	---------------------	
CP 82-1172	147.9	206.1	67.3	140.4
CP 85-1308	118.7	181.4	107.0	135.7
CP 80-1827	149.7	175.9	74.8	133.5
CP 80-1743	93.8	167.2	124.6	128.5
CP 84-1198	102.7	176.7	103.3	127.6
CP 80-2043	110.3	174.0	97.3	127.2
CP 85-1382	121.3	156.7	95.1	124.3
CP 82-1592	99.9	165.5	99.0	121.4
CP 85-1432	123.8	159.8	80.6	121.4
CP 85-1491	99.0	181.0	78.3	119.4
CP 81-1302	109.2	166.2	81.1	118.8
CP 70-1133	100.2	165.3	87.5	117.7
CP 72-2086	109.0	165.4	78.6	117.7
CP 70-1527	124.6	142.6	84.2	117.1
CP 73-1547	110.0	173.9	63.7	115.9
CL 73-239	88.0	142.8	95.8	108.9
CP 81-1254	114.4	148.3	60.9	107.9
CP 78-2114	101.7	135.4	61.6	99.6
CP 72-1210	99.7	134.8	63.8	99.4
CL 61-620	68.2	138.5	83.5	96.7
Mean	109.6	162.9	84.4	118.9
LSD (0.1)	25.8	21.9	25.0	13.9

Table 4. Plant-cane through second-ratoon sugar yields, measured as Mg ha^{-1}, of 20 cultivars planted following a flooded fallow period at Okeelanta Corp. and harvested mechanically.

Clone	Plant cane	First ratoon	Second ratoon	Mean
	--	Mg ha^{-1}	--	
CP 80-1827	15.15	21.57	9.38	15.36
CP 82-1172	13.30	24.34	8.24	15.29
CP 80-1743	8.70	20.82	15.59	15.04
CP 84-1198	10.40	21.12	13.08	14.87
CP 85-1308	10.54	20.39	12.58	14.50
CP 85-1382	11.47	17.82	11.01	13.43
CP 80-2043	8.54	20.58	10.92	13.35
CP 72-2086	10.51	19.98	9.19	13.23
CP 85-1491	9.77	19.96	9.00	12.91
CP 82-1592	8.51	18.16	12.06	12.91
CP 70-1133	9.01	18.86	10.53	12.80
CP 73-1547	9.77	20.64	7.89	12.77
CP 85-1432	10.94	17.98	9.00	12.64
CL 73-239	9.36	16.32	11.62	12.44
CP 70-1527	11.44	16.13	9.27	12.28
CP 81-1302	9.85	17.50	9.17	12.17
CP 81-1254	11.70	17.60	7.11	12.14
CL 61-620	6.83	16.37	10.67	11.29
CP 72-1210	9.33	15.88	7.55	10.92
CP 78-2114	8.06	15.15	7.04	10.09
Mean	10.16	18.86	10.05	13.02
LSD (0.1)	2.56	3.18	3.07	1.70

Table 5. Plant-cane through second-ratoon sugar concentrations, measured as kg sugar Mg^{-1} of cane, of 16 cultivars planted successively after sugarcane at Okeelanta Corp. and harvested mechanically.

Clone	Plant cane	First ratoon	Second ratoon	Mean
	----------kg sugar Mg^{-1} cane----------			
CP 80-1743	106.8	129.7	137.1	124.5
CP 84-1198	95.6	132.9	136.2	121.5
CL 61-620	103.4	127.5	131.6	120.8
CP 72-2086	90.6	134.2	129.2	118.0
CP 80-1827	98.3	125.9	128.2	117.4
CP 78-1628	89.4	127.9	130.0	115.7
CP 70-1133	94.3	124.4	126.8	115.2
CP 73-1547	90.8	127.3	126.9	115.0
CP 85-1382	93.2	123.2	124.6	113.6
CP 82-1172	85.0	125.5	129.1	113.2
CP 78-2114	89.7	123.5	124.9	112.7
CP 81-1254	83.1	131.6	122.2	112.3
CP 85-1308	86.3	127.2	123.2	112.2
CP 81-1302	84.2	127.9	122.9	111.7
CP 82-1592	84.5	121.3	122.3	109.4
CP 70-1527	81.7	116.5	120.1	106.1
Mean	91.0	126.6	127.2	115.0
LSD (0.1)	7.0	6.2	6.4	3.6

Table 6. Plant-cane through second-ratoon cane tonnages, measured as Mg ha^{-1}, of 16 cultivars planted successively after sugarcane at Okeelanta Corp. and harvested mechanically.

Clone	Plant cane	First ratoon	Second ratoon	Mean
	---Mg ha^{-1}---			
CP 78-1628	95.6	167.1	108.4	123.7
CP 82-1592	73.4	163.4	118.5	118.4
CP 80-1827	79.9	162.9	108.9	117.2
CP 80-1743	47.0	169.9	125.5	114.1
CP 70-1133	82.3	154.9	97.0	111.4
CP 72-2086	68.2	160.8	97.7	108.9
CP 73-1547	77.3	154.4	88.3	106.7
CP 84-1198	70.2	156.7	91.7	106.2
CP 85-1308	50.6	154.9	100.7	102.1
CP 85-1382	65.1	133.0	103.3	100.5
CP 82-1172	59.9	159.6	78.4	99.3
CP 70-1527	72.7	119.9	93.4	95.3
CL 61-620	52.2	131.9	101.6	95.2
CP 78-2114	59.1	130.9	81.4	90.4
CP 81-1254	62.2	127.7	79.6	89.9
CP 81-1302	59.4	122.7	60.2	80.8
Mean	67.2	148.2	95.9	103.8
LSD (0.1)	15.5	16.9	17.6	11.0

Table 7. Plant-cane through second-ratoon sugar yields, measured as Mg ha^{-1}, of 16 cultivars planted successively after sugarcane at Okeelanta Corp. and harvested mechanically.

Clone	Plant cane	First ratoon	Second ratoon	Mean
	---Mg ha^{-1}---			
CP 80-1743	5.02	22.04	17.21	14.75
CP 78-1628	8.55	21.37	14.09	14.67
CP 80-1827	7.85	20.51	13.96	14.11
CP 82-1592	6.20	19.82	14.49	13.51
CP 72-2086	6.18	21.58	12.62	13.46
CP 84-1198	6.71	20.83	12.49	13.34
CP 70-1133	7.76	19.27	12.30	13.11
CP 73-1547	7.02	19.66	11.21	12.63
CP 85-1308	4.37	19.70	12.41	12.16
CL 61-620	5.40	16.82	13.37	11.86
CP 85-1382	6.07	16.39	12.87	11.77
CP 82-1172	5.09	20.03	10.12	11.75
CP 81-1254	5.17	16.81	9.73	10.57
CP 78-2114	5.30	16.17	10.17	10.54
CP 70-1527	5.94	13.97	11.22	10.38
CP 81-1302	5.00	15.69	7.40	9.36
Mean	6.10	18.79	12.23	12.37
LSD (0.1)	1.55	2.44	2.36	1.34

Table 8. Stability-safety indices and sugar and cane yields for combined analysis of nine cultivars planted in all three experiments[†]

Clone	Stability-safety index			Yield		
	SC‡	CY‡	SY‡	SC	CY	SY
				kg Mg^{-1}	-----Mg ha^{-1}-----	
CP 80-1827	57.3	-6.0	-4.9	117.0	124.5	14.8
CP 70-1133	54.8	-11.8	-6.0	113.2	113.5	13.2
CP 72-2086	48.4	-13.6	-6.4	115.5	110.5	13.2
CP 85-1308	51.4	-23.6	-6.6	112.9	112.6	13.2
CP 85-1382	54.8	-13.6	-6.4	112.9	110.3	12.7
CP 81-1254	50.1	-27.5	-7.7	112.6	102.6	11.8
CL 61-620	59.3	-40.6	-8.2	118.9	95.4	11.7
CP 70-1527	48.8	-24.8	-8.3	107.5	104.1	11.4
CP 78-2114	48.4	-28.4	-8.5	109.8	93.7	10.5
Mean	53.5	-21.1	-7.0	113.4	107.5	12.5
LSD (0.1)				3.7	9.8	1.2

[†] For these analyses, each harvest at each location was treated as a location. Thus there were eight locations; the plant-cane through second-ratoon harvests at both Okeelanta experiments and the plant-cane and second-ratoon harvest at the New Hope experiment.

‡SC is sugar concentration, CY is cane yield, and SY is sugar yield.

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PROCESSING OF SUGARCANE RIND INTO NON-WOVEN FIBERS

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ABSTRACT

This process was developed for conversion of sugarcane rind to non-woven fibers. It includes partial, directional delignification, and optional agitation and/or tumbling preceding washing and subsequent steam explosion steps. The ultimate fibers in sugarcane rind are similar to those of hard wood, 2 to 5 mm long. Therefore, for these non-woven fibers to be useful raw material for applications such as yarn spinning and geotextile mats, they should be at least 2.5 cm long. A typical sugarcane crushing process causes the length of bagasse segments to be too short; hence not suitable for this study. Instead, a cane separation process similar to that referred to as the "Tilby Process," was used to prepare the sugarcane rind. In this separation process, the cane is split longitudinally in two halves, the high sucrose content pith routed out, and the resulting rind used for this process. The typical treatment in this process is to react 0.1 N NaOH at 166°C (steam pressure 620 kPa) with the rind segments in a reactor designed to specific chemical and mechanical actions. The wet and partially delignified fiber bundles can be damaged by complete rotatory action of an impeller in the reactor; therefore either an oscillating agitation and/or tumbling of the reactor around its horizonal axis was employed. In this paper all runs included tumbling and also some feature agitation. Since the rind is encouraged to split longitudinally rather than transversely by the mechanical action, lignin is removed preferentially in the longitudinal direction. As a result bundles of fibers from the rind are successively reduced in cross section with slight reduction in length, thereby yielding fibers with the necessary length and desired cross section for conversion to other useful products.

Keywords: Fiber, Lignin, Non-woven, Rind, Steam Explosion, Sugarcane.

INTRODUCTION

The ultimate objective of this research is to develop a commercial process for production of non-woven fibers from sugarcane. In this study, the concept of the severity factor (Focher, 1991) and the modified form (Collier, 1992) were further modified to account for mixing and steam explosion effects. The accuracy of the later mathematical correlation was tested for the capability to predict the suitable reaction conditions for conversion of sugarcane rind into non-woven fibers.

Bench scale results have shown that solutions of sodium hydroxide can be used to extract fiber bundles from sugarcane rind (Agrawal, 1992). Alkaline concentration, temperature, and extraction time were found to be the main variables to be controlled for extraction of useful fiber bundles (Collier, 1992).

In this research (Elsunni, 1993), a pilot scale batch reactor was used to further establish the optimum extraction conditions. The Tilby separation process was used to prepare the cane rind segments. It was found that pretreatment of rind with water, followed by 0.1 N alkaline treatment at 166°C for one hour decreases the size and flexural rigidity of the extracted fibers. Oscillatory or tumbling mixing during treatment followed by steam explosion enhanced fiber separation resulting in fine, fluffy, and semi-dry fibers suitable for yarn spinning.

MATERIALS AND METHODS

(a) Sugarcane Sample Preparation:

Fresh and well burnt sugarcane samples were collected from the cane yard of Cinclare sugar mill in Brusly, Louisiana. Typical dimensions of a sugarcane stalk in the sample was 1.5 to 3 meters in length and 18 to 50 mm in diameter. The stalks were then cut into billets of 450 to 600 mm long in preparation for rind separation through the Tilby cane separator.

(b) Cane Separation System:

The cane separation technology developed by Tilby (1976) was actually developed not only to produce sugar and improve its quality, but also to widen the range of by-products of the sugarcane industry. The separator used in this study was a pilot scale unit (Figure 1). The sugarcane billets were hand fed to the positioning rollers, that in a larger scale unit would be rotating at a speed synchronized with the subsequent rollers. These rollers guide and force a billet against a sharp knife which splits it into two longitudinal halves. Each of the two halves goes through a system of two rollers adjacent to each other at a clearance of 1.5 mm. The outermost rollers, 140 mm in diameter, were designed to grip on the outer surface of the half billets and control their forward traveling speed at 550 rpm. The inside rollers, depithing wheels, are 200 mm in diameter, have longitudinal cutting knives, and rotate in the opposite direction at twice the speed of the outer rollers. The half billets start to flatten, once caught between the two rollers, and the high speed depithing wheels start to scrape off the pith portion of the half billets. The rind strips as obtained from the cane separator were 450 to 600 mm in length.

(c) Pilot Reactor:

The pilot reactor used in this study was operated on a batch basis, with special emphasis on the effects of mechanical action and steam explosion on the degree of fiber opening. The reactor body is made of two concentric stainless steel cylinders having inside diameter of 225 and 300 mm respectively (Figure 2). The annulus of the cylinders is connected to a steam source for heating of the inner tube contents. The bottom of the reactor has a conical shape tapering down to a 50 mm discharge line. The discharge is controlled by a 50 mm stainless steel ball valve rated at 3.4 MPa. The top of the reactor is flanged with a 25 mm thick stainless steel ring with 12 equally spaced 16 mm holes. The reactor cover is 25 mm thick and has a 350 mm diameter. Temperature and pressure gauges are installed on the top cover. The reactor is equipped with an oscillatory agitator powered with a 30 watt DC motor to provide mechanical action for the reactor contents. The nominal capacity of the reactor is 20 liters. The reactor was kept tumbling around its horizontal axis at 0.5 rpm in all of the lignin extraction steps.

(d) Extraction Method:

In this study, the extraction method refers to the removal of controlled amounts of lignin from sugarcane rind. Extraction was carried out in three main steps; water pretreatment, alkaline treatment, and steam explosion.

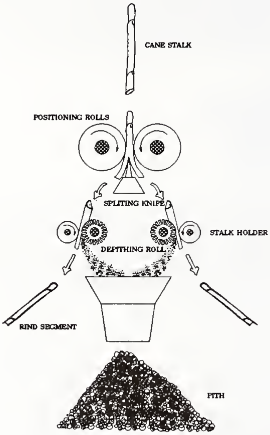

Figure 1. Tilby Separator

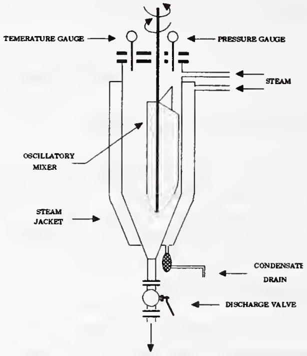

Figure 2. Batch Pilot Reactor

The rind strips as obtained from the cane separator were 450 to 600 mm in length. The strips were cut into shorter segments 75 to 85 mm long, and the nodal regions, which contain shorter and hard fibrous tissues, were discarded. For water pretreatment, the rind pieces were washed to remove loose fiber, pith, and dirt, and then 0.5 kg of rind at 33% moisture were placed in the reactor with 16 liters of water. The cover, discharge, and vent valves were closed, and steam valve opened to permit flow through the reactor jacket. The reactor temperature was maintained at 138°C (saturated steam pressure 240 kPa) for 30 minutes. No mechanical mixing was applied at this stage. When the reactor was sufficiently cooled, the discharge valve was opened and the pretreatment liquor was discharged.

For the treatment phase, 16 liters of sodium hydroxide solution at a selected normality were added to the rind. The reactor was heated to 166°C (saturated steam pressure 620 kPa) and maintained pressurized at that temperature for one hour. Depending on the treatment run requirement, the appropriate oscillatory mechanical mixing was applied during the heating interval. The mixer was an oscillatory type agitator with Y-shaped vanes powered by a 30 watt variable speed DC motor. The agitator was mounted on the reactor top cover, with the mixer shaft vertical but off the center position by 65 mm (Figure 2). The mixer speed was measured on a linear scale of zero to ten, with the value ten corresponding to 100 oscillations per minute. A speed of 8.5 (85 oscillation per minute) was used to provide gentle mixing. A maximum angle of rotation of 32° was used initially, but was later increased to 80° for better mixing effect. The higher angle of rotation was suggested after a study was conducted on the mixing pattern inside the reactor.

After treatment, the steam valve was then closed and the reactor was allowed to cool down. The rind pieces were then tender, soft, and easily separated into bundles, but, while wet, they can be damaged by vigorous handling. Samples of the extracted liquor were also collected for analysis. The rind was flooded with water to wash off any alkaline residues. For subsequent separation of the fiber bundles, the rind was either transferred to a fluidized bed dryer or subjected to steam explosion.

(e) Fluidized Bed Dryer:

The fluidized bed dryer (Figure 3) is a vertical 75 mm diameter glass cylinder of 750 mm in length. The bottom end of the cylinder is tapered to a diameter of 12 mm. The bottom end is connected to a hot air blower, whereas the top is connected by a flexible tube to a horizontal expansion chamber of 200 mm in diameter and length. The open end of the expansion chamber is covered by a fine mesh fabric, to resemble a bag house, through which air can pass but not fibers.

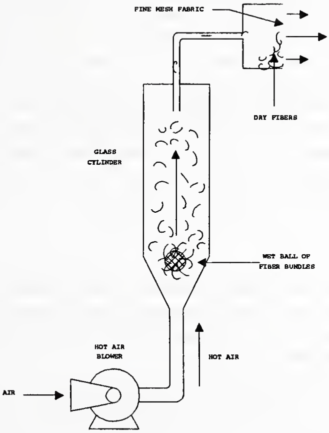

Figure 3. Fluidized Bed Dryer

Drying was achieved by dropping small lumps of extracted fibers into the vertical cylinder. The hot air blowing from the bottom gradually removed the moisture from the rind, causing the fibers to float up and down in small balls. The rubbing action between these balls disentangled the fiber bundles. When dry, the hot air current pneumatically conveyed the fibers through the tapered top end to the bag house, where the air passed through the fabric cover and the fibers were retained. The fibers were then collected for measurement and characterization.

(f) Steam Explosion:

For separation by steam explosion (Hilton, 1990), the treated rind was de-watered by directly blowing low pressure steam inside the reactor, with the discharge valve cracked open. The de-watering continued for about five minutes or until water drops are no longer coming out of the reactor. The discharge valve was then closed and the rind inside the reactor was pressurized to 0.83 MPa (177 °C) by direct injection of saturated steam. The steam was maintained at this pressure for four to five minutes. To insure proper heat distribution, the condensate was continuously removed from the inside of the reactor by means of a condensate trap. After the rind cooking was accomplished, the pressure was suddenly released by rapidly opening the discharge valve. The explosive decompression forced the rind out of the reactor through the discharge valve to the atmosphere. The thermomechanical effect of this sudden expansion enabled extensive fiber bundle separation (Focher, 1991).

RESULTS AND DISCUSSION

The effects of the delignification and steam explosion operative conditions on sugarcane rind were analyzed by characterizing the extracted fibers. The process variables were alkaline concentration, temperature, mechanical mixing, and treatment time. For this study, it was most suitable to keep the pretreatment and treatment temperatures at 138 and 166°C, respectively. These temperatures are above the melting temperature of lignin (125°C), but well below its degradation temperature (195°C), and that of the cellulosic fibers (260°C) (DeLong, 1990). Furthermore, undesirable color development should be minimized as a result of using these temperatures for pretreatment and treatment. During the steam explosion process, the rind was subjected to 0.935 MPa, 177°C saturated steam. For the runs without alkaline treatment, this higher temperature is critical in weakening the lignin/xylan cross-link, and thus separating the fiber bundles by thermomechanical decompression of the rind. Due to the short explosion time, it is less likely that the fibers develop or retain much coloring matter. The alkaline treatment time was chosen as one hour throughout the experimental runs (Collier, 1992). Thus, use or non-use of a pretreatment step, oscillatory agitation, steam explosion, and the alkaline concentration were the only parameters varied from run to run.

(a) Lignin Removal:

The ultimate fibers from the sugarcane rind are too short (2 to 4 mm) (Van Dillewijn, 1952) to be processed into yarn. A selected amount of the lignin originally in the rind should be retained in the final fiber bundles to hold and bond the ultimate fibers and make it possible to obtain fiber bundles of controlled properties.

Two experimental runs were performed to determine the total lignin content in the sugarcane rind. Both runs had identical extraction conditions, where 0.5 kg of rind (33% moisture) were treated in the reactor using 16 liters of 1.0 N sodium hydroxide solution. To insure a high degree of lignin extraction, the reactor temperature was maintained at 166°C for seven hours. During the extraction time, mechanical action was applied by operating the oscillatory agitator at its full speed of 100 oscillations/minute, and continuously tumbling the reactor around its horizontal axis at a rate of 18 revolutions/hour. Table 1 shows the results of the extract analysis of the two experiments. The lignin values obtained were consistent with values reported in literature (18 to 24%) (Paturau, 1969).

Table 1. Experimental estimation of total lignin in sugarcane rind.

Run	Rind (gm) (0% moisture)	Lignin removed (gm)	% Lignin in dry rind
1	335	82	24
2	335	75	22

According to the characterization results obtained, it was found that treatments with sodium hydroxide solutions of 0.1 N under the reactor conditions set forth gave fairly spinnable fibers. A total of eight runs related to textile fiber preparation were performed; 0.1 N alkaline solutions was used in the first six runs and 0.4 N in the last two. Table 2 shows the amount of lignin removed in each of the treatments. In experiments 1 to 3 there was no mechanical mixing applied, whereas in 4 through 8 mixing at 85 oscillations/min was applied during the treatment time.

For the same treatment conditions, more lignin was extracted when the reactants were gently mixed, compared to extraction without agitation. Therefore, for a targeted percentage of lignin to be removed, mixing can be used to enhance the reaction and to decrease the concentration of the alkaline solution needed.

Experimental runs 7 and 8 in Table 2 were performed as part of the search for the optimum alkaline normality that was suitable for extraction of spinnable fibers. In both of these two runs, mixing was applied at 85 oscillations/min. They are shown here to demonstrate the effect of increased alkaline concentration on increasing the amount of lignin that could be extracted under the same pretreatment and treatment temperature and time as in experiments 1 to 6. The amount of lignin extracted is apparently not linear with alkaline concentration, but increasing alkaline concentration from 0.1 to 0.4 aided in lignin removal. This result suggests that at temperatures above the melting point of lignin and lower than its degradation temperature, the amount of lignin that can be extracted may be a weak function of the alkaline concentration. This is consistent with literature recommendations (Focher, 1991) and industry practice (Stephenson, 1950) for extraction of cellulosic lignin with weak alkaline solutions.

Treatment time for fiber extraction was the most effective, and important, reaction variable in rind delignification (Arora, 1993), assuming that the treatment temperature was maintained above that of lignin melting point. The other two possible independent variables were alkaline concentration and mixing effects (which could be expressed in terms of agitation intensity). Mild mixing, at a rate appropriate for fiber extraction, was found to enhance the rate of delignification by about 20%.

Table 2. Experimental mean values of lignin extracted.

Run	Mixing (Oscillations/min)	NaOH solution (N)	Lignin removed (Gm)	Lignin removed % dry rind(1)	Lignin Removed(2) %
1	0	0.1	40	12.0	52.0 .
2	0	0.1	39	11.6	50.4
3	0	0.1	45	13.4	58.3
4	85	0.1	47	14.0	60.9
5	85	0.1	50	14.9	64.8
6	85	0.1	50	14.9	64.8
7	85	0.4	56	16.7	72.6
8	85	0.4	62	18.5	80.4

(1) Basis of 335 gm of 0% moisture cane rind; using 500 gm of frozen rind containing 33% moisture.
(2) Based on 23% total lignin in dry rind.

(b) Reactor Mixer:

The effect of mixing action on lignin extraction and fiber separation was investigated. To understand the mixing pattern inside the reactor, a transparent polycarbonate reactor was constructed from 10 liter carboys to replicate the pilot batch reactor in configuration and capacity. Both reactors have similar dimensions and capacities; the major difference between the two reactors was that the material of construction of the replica was too weak to withstand the treatment pressure. Hence, the carboy reactor could only be operated under atmospheric pressure. The mixing pattern in the replica was assumed to simulate the actual pattern in the pressurized batch reactor.

The polycarbonate reactor was loaded with 0.5 kg of clean, 75 mm long, pieces of sugarcane rind and 16 liters of hot water. It was sealed and the agitator started. Different mixer speeds were used and the corresponding patterns were captured and recorded on a video tape. The following qualitative observations were made:

1. No significant mixing occurred at 70 oscillations/min, and most of the rind pieces were resting in the bottom of the reactor.

2. At 80 oscillations/min, about 50% of the rind started to float randomly, but did not appear to have a definite pattern.

3. At 90 and 100 oscillations/min, about 60 to 70% of the rind was moving in an oriented motion, from bottom, upward over the top of the mixer vanes, and then downward to the bottom. Although this was the general mixing pattern at these higher speeds, still there remained a significant amount of rind (about 20%) that was either moving at random and

out of the observed pattern or was at rest in the bottom of the reactor.

4. The angle of oscillation of the mixer vanes was small (32°). This limited motion of the vanes resulted in no mixing effect at most of the mixer speeds.

To improve the mixing effect, the mixer driving mechanism was modified and the angle of oscillation increased to 80°. The carboy reactor was used once more to study the effect of the modification in the rind motion. Two important pattern changes were observed when the mixer was operated at 80 to 90 oscillations/min.

The first observation was the total movement of the rind segments in a well defined pattern at the mixer speed of 85 osc/min. The segments move from the bottom towards the reactant surface where they change direction to pass over the mixer vanes and then drop towards the bottom.

The other noticeable change was the directional twisting of rind segments by the vanes sides. On their way down, the segments pass between the mixer V-shaped vanes and the reactor walls. Although most of the rind segments continue the journey directly to the bottom, about 15 to 20% exit the passage from clearances that appear momentarily between the vanes sides and the reactor walls. Because these clearances are narrow and the mode of motion is downwards, the segments exit the passage while their lengths are parallel to the vanes edges. The angular motion of the vanes forces the segments out of the passage in a swirling motion to the reactor bulk which is moving upward. This behavior may enhance delignification and directional separation of fibers.

(c) Alkaline and Rind Loading Ratio:

Important treatment parameters were the alkaline solution and rind loading ratio. During the course of this research, the mass ratio of solution to rind was kept at 32 to 1. The configuration of the reactor discharge valve and the low power of the mixer limited the quantity of rind per batch. The reactor has a 20 liter volume, with 16 liters as the working capacity, a 50 mm discharge valve diameter, and a 30 watt mixer. For all of the pilot reactor experiments, the reactor was tumbled at a rate of 0.5 rpm.

At the loading ratio of 32 to 1, the mixer speed was maintained at 85 oscillations/min. When the rind portion was doubled in two experiments (16 to 1 loading ratio), it was observed that the mixer slowed down to less than 42 oscillations/min, at the same input voltage setting, and that the agitator frequently stopped. Moreover, after the liquor was drained, the treated rind settled in the reactor conical bottom, and could not be blown out when the discharge valve was opened for steam explosion. Instead, the rind jammed in the pipe leading to the discharge valve. A higher loading ratio could have been used if either the discharge valve had been larger in diameter and/or the mixer were more powerful.

Another factor that influenced the loading ratio was the length of the rind pieces. The segments that were subjected to treatment were 75 to 100 mm in length. After treatment, these pieces lose their hardness and rigidity and become much softer and more flexible and are entangled with each other. The extent of entanglement clearly depends on the starting length of the rind segments. Longer segments require a larger upstream pipe, a larger discharge valve diameter, and a more powerful mixer.

(d) Heat Transfer and Steam Requirement:

Solids with low or poor thermal conductivity can be treated rapidly and uniformly in the presence of liquids. During the alkaline treatment of rind, heating to the reaction temperature was achieved within 5 to 6 minutes. Assuming a well designed reactor jacket, the short heating time was mainly due to the high thermal conductivity of water or alkaline solution. The high ratio of solution to solids was another parameter that contributed to the shorter heating time.

Bone dry rind and woody material in general are known for their resistance to heat transfer. In preparation for the steam explosion process, the treated rind (440 gm at 30% moisture) had to be heated to 177°C and then maintained at this temperature for at least one minute before it could be exploded. It was found that a heating time of 6 to 8 minutes per kilogram of rind (30% moisture) was required to reach the explosion temperature. This time was longer than the time required per kilogram of reactor content during the treatment phase. The semi-dry cellulosic mass was indeed a limiting factor for rapid and uniform heat transfer. Heating of rind in the absence of an aqueous phase was one of two constraints for the steam explosion of rind. The other constraint was the need for continuous removal of condensate that forms during the steaming and pressurizing process. To overcome these two constraints, an optimum moisture content of 50 to 60% by weight was required for fair explosion results. High water content in the rind lowered the temperature inside the cellulosic cells and resulted in poor fiber separation upon explosion. Rind with low moisture content however may resist penetration of heat to the inner cells.

(e) Severity Factor:

The concept of a severity factor was introduced by Chornet and Overend (Focher, 1991) to account for the complex kinetics associated with processing of lignocellulosic in aqueous-steam systems. A modified form of the severity factor was later developed by the Colliers and co-workers (Collier, 1992), as in Equation 1, to measure the severity of the delignification conditions on the fiber quality.

$$R = t_{pre} \exp\left(\frac{T_{pre} - T_b}{14.75}\right) + t_{tr}\left[\exp\left(\frac{T_{tr} - T_b}{14.75}\right) + KC\right] \qquad (1)$$

Where :
R = Severity factor.
t_{pre} = Pretreatment time (minutes).
t_{tr} = Treatment time (minute).
T_{pre} = Pretreatment temperature (°C).
T_{tr} = Treatment temperature (°C).
T_b = Base temperature (°C).
C = Alkaline solution concentration (N).
K = Kinetic factor, to be evaluated.

In this study, the severity factor was further modified to account for the effects of mechanical mixing and steam explosion. A mixing factor, f_m, defined as the ratio between the amount of lignin extracted by treatment with mechanical mixing applied to the amount extracted under the same conditions but with no mixing involved was used. The modified form of the severity factor expression (Elsunni, 1993) is shown in Equation 2.

$$R = t_{pre} \exp\left(\frac{T_{pre} - T_b}{14.75}\right) + f_m t_{tr} \left[\exp\left(\frac{T_{tr} - T_b}{14.75}\right) + KC\right] + t_{ex} \exp\left(\frac{P_{ex} - P_o}{P_o}\right) \qquad (2)$$

Where,

$$f_m = Mixing\ \ factor \ = \frac{Lignin\ \ Extracted\ \ \ with\ \ Mixing\ \ Applied}{Lignin\ \ Extracted\ \ \ with\ \ no\ Mixing}$$

t_{ex} = Heating time prior to steam explosion (minutes).
P_{ex} = Steam explosion pressure (psig).
P_o= Reference pressure (atmospheric pressure, psia).

$$L_n = \frac{1}{K} \ln\left(R_n\right) \qquad (3)$$

For no mixing and no steam explosion performed, f_m becomes 1, and t_{ex} is zero, causing equation 2 to reduce to equation 1. The factor K was assumed to be constant and have the same value for reactions of lignocellulosic with sodium hydroxide solutions. It was evaluated by relating the amount of lignin removed to the natural logarithm of the severity factor (Collier, 1992).Where,
L_n = Amount of lignin removed by process condition n.
R_n = Severity factor for process condition n.

Equations 2 and 3 were solved simultaneously to evaluate R and K.The reaction variables and the amount of lignin removed in three runs that involved no mixing or steam explosion were used to determine the average value of severity factor and the corresponding value of K. In each of the three runs, the pretreatment temperature and time were 138°C and 30 minutes, and the treatment was at 166°C for 60 minutes. Table 3 shows the calculation results for each of the three experiments and the corresponding means.

The average K value obtained was used in Equation 2 to evaluate the severity factor for reactions with different extraction conditions. For comparison purposes, the pretreatment and treatment temperature and time were held constant. Also the mixing factor f_m and the steam explosion time were set at 1.2 and 1 minute, respectively. Table 4 shows the effect of increased concentration, mechanical mixing, and steam explosion on the severity factor magnitude. This magnitude of the severity factor was explored as a possible determining characteristic to produce a particular fiber quality. For example, extraction with 0.4 N alkaline solution, mechanical mixing, and no steam explosion had a severity factor of 8670. Treatment with 0.1 N solution, mechanical mixing, and steam explosion, had a severity factor of 8600. The severity factors were similar for these two experiments. Hence,the fibers extracted would be expected to be similar in quality and characteristics if the severity factor was the most significant defining parameter. However, the fibers collected from all experiments with 0.4 N solutions and with either mixing or steam explosion applied, were 20 to 30% shorter in length compared to those extracted with 0.1 N solutions. If Equation 2 is valid, then the differences in fiber qualities could be attributed to the precision in which the two experiments were conducted. Actual temperature variation in all of the experiments performed was about 5°C from the set point. Sensitivity calculations indicated that a 5°C increase in pretreatment and treatment temperatures for experiments with 0.1 N and 0.4 N sodium hydroxide, with mechanical mixing and no steam explosion would result in an increase in the severity factors to 9830 and 11300, respectively. This dramatic increase in the severity factor due to small variations in temperature, explains the importance of precision required in performing delignification reactions should the fibers characteristics be a function of severity factor. Of course it is also possible that other factors such as aqueous solution alkalinity, reaction time, and mixing are critical.

Figure 4 is a graphical representation of the effect of increased alkaline concentration, mixing, and steam explosion on the magnitude of the severity factor. It can be seen that the effect of steam explosion on the severity factor at any particular alkaline concentration, is equivalent to the effect that results in increasing the alkalinity of the aqueous phase from 0.1 to 0.4 N.

Table 3. Mean value of kinetic constant K

Run	NaOH solution (N)	Lignin removed gm/gm rind (Bone dry)	Severity factor (R)	Kinetic constant (K)
1	0.1	0.115	6115	75.8
2	0.1	0.120	6096	72.6
3	0.1	0.133	6053	65.5
Mean	0.1	0.123	6086	71.0

Table 4. Effects of mixing and steam explosion on severity factor

Combinations	NaOH solution Normality (N)	Severity Factor (R)
No mechanical mixing No steam explosion	0.0	5660
	0.1	6090
	0.4	7360
Mechanical mixing No steam explosion	0.0	6650
	0.1	7150
	0.4	8670
No mechanical mixing Steam explosion	0.0	7110
	0.1	7530
	0.4	8810
Mechanical mixing Steam explosion	0.0	8090
	0.1	8600
	0.4	10100

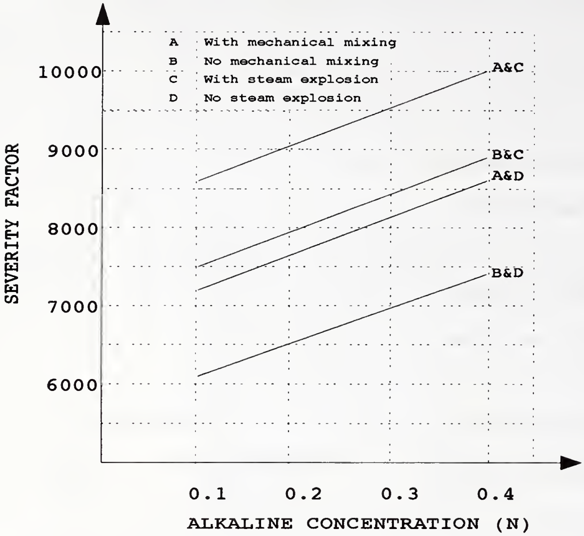

Figure 4. Effect of Reaction Parameters on Severity Factor

(f) Fiber Extraction, Process Recovery:

The objective of this portion of the study was to determine the optimum reaction conditions for extraction of spinnable textile fibers. The fibers obtained were spun into yarns of 1:1 blend of cane fiber and cotton. The amount separated and prepared for spinning constituted a small percentage of the cane rind that was subjected to extraction. Cane variety and precision in extraction variables control were believed to be the main factors that influenced the percentage of spinnable fibers obtained. Table 5 shows the fiber characterization results for three experiments; four replicates of each quantity were measured for each experiment. Each of the runs was subjected to treatment with 0.1 N alkaline solution without agitation and with steam explosion. The calculation of percent spinnable fiber is shown below based on 0.5 kg of rind at 33% moisture in each charge:

- Bone dry rind = 500 X (1-0.33) = 335 g
- Average lignin extracted = 335 X 0.123= 41.2 g
- Available mass of fiber for steam explosion= 335 - 41.1 = 293.8 g
- Actual mass of fiber obtained after steam explosion = 252 g
- Spinnable fiber percent exploded fiber (actual) = 5.4%
- Mass of spinnable fiber = 252 X 0.054= 13.6 g
- Spinnable fiber percent rind = (13.6/335) X 100 = 4%

The distance of the target at which exploded rind impacts influences fiber characteristics greatly. Fibers of experiments 1 and 2 in Table 5 were exploded towards solid targets that were 3 and 5 meters away respectively, from the reactor discharge valve. Because the exiting fibers had high momentum and the target surface was relatively close, the explosion resulted in a severe impact, strongly affecting the fiber characteristics. The impact caused the fibers to break into small pieces that were shorter than needed for spinning. In experiment 3 however, the target was located at a distance of more than 20 meters, and in that configuration the exploded fibers barely reached the target. Thus, the percent of spinnable fibers in experiment 3 was considerably higher (3 to 4 times) than in experiments 1 and 2.

Treatments that involved mechanical mixing but no steam explosion were found to result in a lower percentage of spinnable fibers. Table 6 shows the percent spinnable fiber in treatments with 0.1 N solutions, mechanical mixing, and no steam explosion. It can be seen that the percent of spinnable fibers in the three runs was more or less consistent. The number of fibers suitable for spinning found in a 0.1 gm sample without steam explosion was consistently lower than those with steam explosion as reported in Table 5. In steam exploded rind, the fraction of fibers considered not suitable for spinning were essentially too short to spin. Fibers extracted by treatments that involved mixing but no steam explosion were longer, thicker, and had a higher linear density. This resultant thicker characteristic caused a large fraction of fibers to not be suitable for spinning. According to the severity factors in Table 4, the treatments in Table 6 have a severity of 7150, compared to 7530 for run 3 in Table 5. The coarser fibers may possibly be attributed to the relatively lower severity factor of experiments 4, 5, and 6 reported in Table 6.

CONCLUSIONS AND RECOMMENDATIONS

In this study, non-woven fibers were extracted from sugarcane rind using a pilot scale batch reactor. Alkaline concentration, oscillatory mixing, and steam explosion were the main extraction variables. For all experiments, temperature and time were set at 166°C and 1 hour, respectively. The other variables were varied to determine the optimum extraction conditions.

Delignification of cane rind with alkaline solution of 0.1 N was found to result in spinnable fibers with fair quality. Treatments were performed at 1:32 mass ratio of rind to solution. Incremental amounts of lignin extracted by increased alkaline concentration decreased at higher concentrations, indicating that weaker alkaline solutions were proportionally more effective than stronger solutions.

The effects of oscillatory mixing and steam explosion on rind delignification and fiber bundle separation was evaluated by a modified form of the severity factor correlation. The magnitude of the severity factor can be used to predict and/or tailor the textile characteristics of the extracted fibers. Adequate mixing and steam explosion were found to increase the severity factor magnitude by 15 and 25% compared to no mixing and no explosion, respectively. In general, oscillatory mixing was found to enhance rind delignification, whereas steam explosion causes the rind to separate into finer semi-dry fiber bundles. Treatments that were not followed by steam explosion resulted in thicker and coarser fibers. The use of the severity factor correlation showed that the extent of delignification can increase or decrease significantly should the reaction temperature depart the set point by more than 3 to 5° C.

Table 5. Characterization of spinnable fiber bundles extracted with 0.1 N NaOH, without agitation, and with steam explosion.

Properties	Replicate	Experiment number			
		1	2	3	Mean
Number of fibers in 0.1 gm of Exploded rind	1	4	10	33	15
	2	8	3	18	9
	3	3	6	20	10
	4	5	4	17	9
	Mean	5	6	22	11
Linear Density (Tex)	1	16	9	7	11
	2	11	9	7	9
	3	9	9	6	8
	4	6	11	6	8
	Mean	10.5	9.5	6.5	9
Mean fiber length (mm)	1	22	29	27	26
	2	28	29	33	30
	3	21	25	32	26
	4	24	27	31	27
	Mean	24	27.5	31	27
Spinnable fiber % exploded rind	1	1.4	2.3	5.7	3.1
	2	2.3	0.75	5.4	2.8
	3	0.6	1.4	5.6	2.5
	4	0.73	2.5	4.7	2.6
	Mean	1.26	1.74	5.35	2.75
Spinnable fiber % bone dry rind	1	1.05	1.73	4.29	2.4
	2	1.73	0.56	4.06	2.12
	3	0.45	1.05	4.21	1.9
	4	0.55	1.88	3.53	1.99
	Mean	0.95	1.31	4.02	2.10

Table 6. Characterization of spinnable fiber bundles extracted with 0.1 N NaOH, agitation, and no steam explosion

Properties	Replicate	Experiment number			
		4	5	6	Mean
Number of fibers in 0.1 gm of Exploded rind	1	10	4	3	6
	2	5	8	3	5
	3	7	6	2	5
	4	10	5	2	6
	Mean	8	6	3	6
Linear density (Tex)	1	9	23	15	16
	2	10	13	21	15
	3	9	8	18	12
	4	10	13	20	14
	Mean	10	14	19	14
Mean Fiber Length (mm)	1	26	29	22	26
	2	23	26	27	25
	3	24	25	22	24
	4	30	27	30	29
	Mean	26	27	25	26
Spinnable Fiber % Exploded Rind	1	2.5	2.4	0.95	1.95
	2	1.3	2.7	1.70	1.9
	3	1.9	1.6	0.75	1.42
	4	3.4	1.8	1.2	2.13
	Mean	2.28	2.13	1.15	1.84
Spinnable fiber % bone dry rind	1	1.88	1.80	0.71	1.46
	2	0.98	2.03	1.28	1.43
	3	1.43	1.20	0.56	1.06
	4	2.56	1.35	0.90	1.6
	Mean	1.71	1.6	.86	1.4

ACKNOWLEDGEMENTS

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PEER

REFEREED

NOTES

MANUFACTURING

SECTION

MILL IMPROVEMENTS AT CORA TEXAS

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Several improvements were made at the Cora Texas mill in 1994. These are discussed below.

1. The addition of a fourth Cameco 45° cane wash table. Presently, we are washing approximately 125 tons of cane per hour on each table, and we are using approximately 8,000 gallons per minute of water per table. This is giving us much cleaner cane to grind and a more even feed to the mill.

2. The main cane carrier chain was changed from a 6 inch pitch to a much heavier 8 inch pitch, 215,000 lb average ultimate strength chain. We also replaced the idler rollers on the return side of the carrier with a slide consisting of two four inch wide Ultra high molecular weight plastic strips. The improvement reduced wear on the chain and eliminated the maintenance required on the idlers.

3. The addition of a third set of knives positioned before the two existing sets of knives. This set of knives set 32 inches above the carrier, turning counter-current of the cane coming in and driven by a 650 hp turbine, not only leveled the cane coming in, but also took a considerable load off the other sets of knives.

4. The knife holder design was changed from a one-sided holder with a 1¼ inch grade 8 bolt to a two-sided holder with a 1½ inch cold roll pin. This change strengthened the hold of the knives by the knife coming out of the holder. Previously, we had problems because of a bolt breaking and the knife coming out of the holder. This change eliminated the problem of knives coming out of their holders.

5. The addition of domite tips on all three sets of knives enabled us to grind 773,794 tons of cane without changing an entire set of knives. This was a first for Cora Texas.

6. The installation of a new mill feed control system. This Donnelly chute level control system consists of a six inch wide plexy glass strip with ten carriage head bolts. The level in the Donnelly chute is converted through conductance by a Betz engineering level control board to a four to twenty milliamperes signal. This signal is then used by a Moore 352 controller to control the level in the No. 1 Donnelly chute, by varying the speed of the main cane cutter. If any of the three sets of knives slows to 90% of running speed, then control of the carrier transfers and is controlled by the speed of that set of knives. Furthermore, if any of the sets of knives slows to 80% of running speed, then the carrier stops. When the knife speed returns to normal, the carrier ramps back up to full speed in 15 seconds. Then, the controller returns to normal and controls the level in the No. 1 Donnelly chute. The new feed system gives a much steadier feed than the old system that would stop and start the carrier every time a set of knives would slow down to 85% of normal speed.

7. Liquefied chlorine gas, contained in 1 ton steel cylinders, has been used at Cora Texas during past years for mill sanitation. A chlorinator was used to produce chlorinated water that was dripped into the last mill and limed juice tanks at a rate of about 3 parts

per million on cane. In 1994, the use of gaseous chlorine was discontinued because of the potential danger of a chlorine-gas leak. As a substitute, management decided in favor of liquid sodium hypochlorite (commonly called bleach) for the 1994 crop. It is supplied in totes of 330 gallons each at a cost of $0.70 per gallon. One tote lasted approximately one week of grinding at 11,000 tons per day. This translated to 3.2 parts per million of chlorine on cane, at a cost of about $33.00 per day. The hypochlorite solution was diluted 1:1 with cold water to eliminate crystal formation and facilitate pumping, and was added at the same points of application as before.

However, we soon noticed that the dextran ratio between the mixed juice and the average growers' core sampler juice was much higher than in previous years. Concurrently, it was also observed that the dextran ratio between the mill crusher juice and the core sampler juice was about twice as much as in previous years. It was then decided to switch the application of the hypochlorite solution directly onto the prepared cane, across the whole width of the belt conveyor feeding the Donnelly chute of the first mill. On the discharge side of the hypochlorite metering pump, cold water was added to further dilute the solution. Hot water should not be used for dilution because it is reported that sodium hypochlorite is decomposed by hot water. After the switch of bactericide onto the prepared cane, the dextran ratio between the mill crusher juice and the core sampler juice was lower than in previous years.

8. In the 1993 grinding season, we had one Donnelly chute on the No. 6 mill. For the 1994 season, we added three more Donnelly chutes, on No.1, No. 4, and No. 5 mills. The level control on No. 1 mill Donnelly chute is controlled by the speed of the main carrier. The level in the other three Donnelly chutes is controlled by the speed of the turbine driving that mill. The level in the Donnelly chutes was maintained between 5 and 8 feet over the top roller. We determined the set points of the level in the Donnelly chutes by how much we wanted the top rollers to rise. The addition of these Donnelly chutes on the mills gave us a much steadier feed and eliminated the probability of mill chokes. We also noticed a 20 to 30% reduction in roll speed that gave us more time under compression.

9. We changed the grooving of all six cane rollers from 50° to 40°. This eliminated the need for juice grooves which also eliminated the need for fingers to clean the grooves. We can now move the cane rollers without the previous problem of having to adjust the fingers.

10. We put Zanini L-shaped scrapers on all six mills. The importance of these scrapers is to drain the juice off the top roll so that the juice cannot drain back on the cane coming out of the mill. We also modified these scrapers by adding a 1 inch plate, cut to fit the grooves in the rollers, parallel to the scraper about 8 inches from the top of the scraper. This formed a bagasse seal between the scraper and the plate to better seal the juice from draining through the scraper. We also eliminated the cross chevron grooving on the top roll that improves the juice seal at the L-shape scraper.

11. With the addition of Donnelly chutes and L-shaped scrapers, we were able to use more imbibition water than in previous years. A benefit of greater importance is that we were able to put 100% of the imbibition on the last mill. We were also able to use total compound imbibition on the last two mills.

Due to the mill improvements for the 1994 grinding season, the mill efficiency improved greatly from previous years. Table 1 shows that the results in 1994 were much better without the French Press than in 1993 with the French Press. Due to these results, we have eliminated the need for the French Press at Cora Texas.

For the 1995 crop, we are installing the last two Donnelly chutes complete with level controllers. We are also installing two new mill drives; therefore, each individual mill will have a separate drive. This will enable us to better control each individual mill. This year we also plan to install four pumps without chokes, so we can utilize compound imbibition. We expect these changes to further improve our mill extraction at Cora Texas.

Table 1. Statistics for the 1993 and 1994 grinding seasons at the Cora Texas Factory.

Statistic	1993	1994
Tons cane ground	773,794.00	710,955.00
Grinding rate, tons per hour	447.81	434.60
Pol % cane	12.16	11.64
Fiber % cane	14.10	14.36
Imbibition % cane	32.48	27.06
Reduced extraction	93.83	93.23
Pol % bagasse	2.61	2.80
Moisture % bagasse	53.83	52.86
Lbs 96° sugar per ton cane	212.44	199.53
Liquidation factor	101.00	100.14

AGRICULTURAL ABSTRACTS

Screening Sugarcane Populations for Hybrids using *Erianthus*-Specific Primers and the Polymerase Chain Reaction

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Sugarcane breeding programs would benefit greatly if wide hybrids could be distinguished from selfs at the seedling stage. This is particularly true in the case of sugarcane (interspecific *Saccharum* sp. derivatives) x *Erianthus* sp. crosses in which F_1 hybrids may be difficult to identify on the basis of gross phenotype. These hybrids tend to have wide leaves, large barrel, and moderate to high Brix. D'Hont (Sugarcane Breed. Newsl., Feb. 1995) reported size variation of the 5S-rDNA cluster spacer in *Saccharum* and *E. arundinaceus*, and that polymerase chain reaction (PCR) amplification of this region permitted detection of hybrids between *S. officinarum* and *E. arundinaceus* (2n=60). We applied this technology and attempted to detect hybrids in five populations of sugarcane x *Erianthus* sp. (2n=20). The five populations consisted of 24 to 210 random seedlings each. Sugarcane and *Erianthus* parents each had a PCR product that differed in size (about 250 and 360 base pairs (bp), respectively). Another product of about 60 bp was also observed in several progeny of four of the five populations. Since no progeny possessed both major PCR products of the parents, other primers may be needed to detect hybrids. The experimental protocol and possible reasons for failure to detect hybrids will be discussed.

Harvestability of Recently Released Louisiana Sugarcane Cultivars: LHo 83-153, LCP 85-384, and HoCP 85-845

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Presently, most Louisiana sugarcane farmers use soldier-type harvesters; therefore, harvestability of new cultivars is important to growers and researchers. Three recently released cultivars, LHo 83-153, LCP 85-384, and HoCP 85-845, plus seven older cultivars, CP 65-357, CP 70-321, CP 72-370, CP 74-383, CP 76-331, CP 79-318, and LCP 82-89, were mechanically harvested with a single-row harvester in the plant-cane and first-stubble crops in 1993 and 1994, in a harvestability test at the Ardoyne Farm, Houma, LA. Data collected were stalk brittleness using a hand-held stalk breaking device (SBD), erectness rating at time of harvest, percent scrap after harvest, and percent of stalks damaged by the harvester. An analysis from the two crop years indicated that LHo 83-153 and HoCP 85-845 were equal to the best harvesting commercial cultivars, CP 65-357, CP 72-370, and CP 74-383, in the percent scrap after harvest, percent of stalks damaged by the harvester, and erectness rating. LCP 85-384 had the highest percent scrap and percent of stalks damaged by the harvester when compared to all other cultivars and had a lower erectness rating (was less erect) than CP 65-357, CP 72-370, or CP 74-383. However, LCP 85-384 was significantly higher in sugar per acre than CP 65-357, CP 74-383, or LHo 83-153, regardless of the amount of scrap left in the field.

Effect of a Cold-Soak, Long Hot-Water Treatment on Louisiana Commercial Sugarcane Cultivars

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Among the cultivars recommended for planting in Louisiana at the time leaf scald was discovered in the industry in 1992, three were considered susceptible, four moderately susceptible, and two resistant. The susceptible cultivar, CP 74-383, was removed from the list of recommended cultivars. Until more resistant, well-adapted cultivars are developed, leaf scald in susceptible and moderately susceptible cultivars can be managed through clean seed cane programs. A cold-soak, long hot-water treatment (CS-LHWT) has proven effective in freeing seed cane of the leaf scald bacterium in Australia. The present study was initiated to determine the effect of the CS-LHWT on nine recommended Louisiana cultivars. The procedure involves soaking stalks for 40-48 hours in ambient temperature water followed by 3 hours in 50C water. In two experiments with planting dates of 24 August and 14 September 1994, stalks were cut, treated, and planted immediately to the field. On 9 November 1994, the number of shoots from treated stalks exceeded the number of shoots from non-treated stalks in four of the nine cultivars in the earlier planted experiment and in seven cultivars in the later planted experiment. On 21-22 March 1995, little difference was observed between the number of shoots from treated and non-treated stalks in the earlier planted test; whereas, in the later planted experiment, the number of shoots from the treated stalks was higher than the number of shoots from the non-treated stalks in most cultivars. Buds of Louisiana cultivars survived the CS-LHWT resulting in good spring stand counts. The 1994-1995 winter in Louisiana was mild and results could differ following a winter when treated cane is subjected to frequent and intense sub-freezing temperatures. Results of a test of the efficacy of the CS-LHWT to control leaf scald are incomplete.

Influence of Composted Municipal Waste on Sugarcane Yields and Fertilizer Requirements

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Due to concerns for the environment, many landfills in Louisiana have been closed. Solid waste from many municipalities is trucked to distant landfills at considerable cost. A possible solution to this problem is to make compost from sewage sludge and garbage for use in agricultural production. Our research was conducted to determine whether composted municipal waste, supplied by the Bedminster Bioconversion Corporation, could be used to increase sugarcane yields and decrease inorganic fertilizer requirements. Experimental results from a four-year sugarcane field study showed that: 1) compost was low in heavy metals and fecal coliform levels; 2) 10 T/A of compost semi-banded under cane at planting, when used with the recommended rate of commercial fertilizer, increased total sugar yields over four years by 8.6% (2,010 lbs/A); and 3) application of the recommended rate of commercial fertilizer, where compost had previously been applied (semi-banded under cane at planting), resulted in a positive synergistic effect on sugarcane yields. Consequently, composted municipal waste could have a place in the commercial production of sugarcane.

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Selection for Self-Stripping in Sugarcane Clones (*Saccharum* sp. hybrids)

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Increasing environmental regulations may soon restrict or reduce the extent of field burning for the removal of leafy trash from sugarcane stalks prior to harvest. Further, there is evidence that field burning may actually reduce the quality of harvested cane by reducing the yield of commercially recoverable sugar (TRS) per ton of cane. Also, new technology now makes green-cane harvesting more feasible. In an effort to study the feasibility of selection for self-stripping in sugarcane (*Saccharum* sp. hybrids) which could reduce the need for burning, improve overall cane and juice quality, and better facilitate green-cane harvesting, a study involving 24 crosses with parental clones of self-stripping (SS) or tight clinging (TC) leaves and accompanying leaf sheaths was begun in the spring of 1993 with the following objectives: to determine the genetic behavior of leaf shedding and the relative frequency of self-stripping clones among the progeny; the association between leaf shedding and other agronomic traits of economic importance; and the effectiveness of selection for self-stripping clones in the single stool stage. Two hundred eighty-eight clones each of the 24 crosses representing SS X SS, SS X TC, TC X SS, and TC X TC progeny combinations were set to the field in a four replicate, randomized complete block design with 72 clones per replicate.

Little or no differences were noted in shucking behavior in the plant-cane crop of the single-stool stage, probably due to the immaturity of the crop (six months); however, there were significant differences noted in the first-stubble crop. On 13 October 1994, subjective ratings on a scale of 1 - 9 (1 = self-stripping and 9 = tight clinging leaves and leaf sheaths) were made for self-stripping behavior in the first 50 clones of each replicate for the 24 crosses. The average ratings were as follows: SS X SS, 5.5 (range, 4.8 - 6.5); SS X TC, 6.1 (range, 4.5 - 8.0); TC X SS, 7.5 (range, 7.0 - 8.3); and TC X TC, 8.2 (range, 7.5 - 8.5). Progeny of crosses with the best ratings for self-stripping occurred in the crosses between two self-stripping parents; whereas, progeny with the worst ratings occurred in the crosses between two tight clinging parents with the remaining progenies intermediate. A second assessment was made on 2 November where the leaves and leaf sheaths for each clone were individually classified into three groups: number of clones with stalks with 50% or more of the leaves and leaf sheaths naturally shedding (clean); number of clones with stalks with less than 50% shedding but the remaining leaves and leaf sheaths loosely attached (loose); and number of clones with stalks with tightly clinging leaves and leaf sheaths (clinging). The correlation coefficients between the ratings for self-stripping and number of clones with clean, loose, and clinging leaves and leaf sheaths were r = -0.858, -0.898, and 0.915, respectively, showing very good agreement. Further, the correlation coefficient between the ratings for self-stripping and the number of clones selected for the self-stripping character and replanted to 6-foot line (clonal) trails (n = 381) for the 24 crosses was r = -0.845, again showing close agreement. These data also showed a moderate association between ratings and agronomic type (r = 0.576) and between ratings and overall assessment of the progeny in each cross (r = 0.548) but no association between ratings and erectness of stalks (r = 0.050). Overall, the data suggest that selection for the self-stripping character is feasible and that the self-stripping type may be associated with overall agronomic type. Data to be obtained in the first-clonal trials in 1995 should further help determine if selection for the self-stripping character is effective as early as the single-stool stage.

Polymerase Chain Reaction (PCR) Detection of the Leaf Scald Causal Organism in Infected Sugarcane and Sweet Corn Plants

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A Louisiana isolate of *Xanthomonas albilineans* (*Xa*), *Xa1*, from infected sugarcane variety LCP 82-89, was used as the *Xa* type culture in our studies. When sugarcane and sweet corn seedlings were inoculated with *Xa1* into the leaf whorl by needle injection, typical leaf scald pencil-line symptoms were induced. Using the PCR protocol developed in our lab (Pan et al., unpublished), we were able to detect *Xa* cells in symptomatic and asymptomatic leaf exudates from the sugarcane and corn seedlings inoculated with *Xa1* and other known *Xa* strains. No *Xa*-specific amplification was observed in leaf exudates from control plants. The PCR method also identified *Xa* cells in sap of infected sugarcane stalks. The PCR protocol requires approximately four hours to complete and a material cost per sample of less than $2. Compared to other methods, i.e., isolation on selective medium and serology, the PCR protocol offers enhanced diagnostic accuracy in shorter turn-around time for a cheaper price. It will provide sugarcane growers and researchers with a new tool in the detection of the leaf scald disease and the identification of *Xa*.

Effects of Asulox Application on Johnsongrass Control and Sugar Recovery

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Asulox was applied at a broadcast rate of 4 quarts/acre as a single treatment within 5 days of April 24, May 16, or June 12 and as a sequential treatment on April 24 followed by June 12 to ratoon CP 65-357 and CP 70-321 sugarcane infested with rhizome johnsongrass. Fiber and sucrose levels (% gross cane) and estimated yields of theoretical recoverable sugar (TRS) in reconstituted samples of harvested cane/weed biomass from the heap row were determined using standard core/press analyses. Visual estimates of johnsongrass control made 4 weeks after treatment ranged from 64 to 86 %, as an average of both studies, with control being lowest when Asulox was applied only in June. Gross yields (tons/acre) of green cane of CP 65-357 were higher than the weedy check for all Asulox treatments with the greatest increases occurring when Asulox was applied either sequentially (80%) or as a single application in April or May (55%). Gross yields of green cane of CP 70-321 were higher than the weedy check only when Asulox was applied sequentially (43%) or as a single treatment in April (38%). Johnsongrass biomass production in harvested, green CP 65-357 was similar for the various Asulox treatments and averaged 1100 pounds/acre compared with 4200 pounds/acre for the weedy check. Johnsongrass biomass in green CP 70-321 was less than the weedy check (6700 pounds/acre) only when Asulox was applied sequentially (2800 pounds/acre). However, the total amount of green trash

(crop and weed foliage) for all Asulox treatments was similar to the weedy check in both studies because sugarcane stalk numbers were higher where Asulox controlled the johnsongrass.

Fiber content in green cane was reduced by 2.3 (CP 65-357) and 6.1 (CP 70-321) points when Asulox was applied as a sequential treatment. Similar reductions were observed when single applications of Asulox were made in April or May. Reductions in fiber content resulting from treatment with Asulox were offset in CP 65-357 by an 0.8% drop in sucrose when Asulox was applied in May and as a sequential treatment. Asulox application did not affect CP 70-321 sucrose levels. As a result, TRS values were similar to the weedy check when Asulox was applied to CP 65-357, but higher when Asulox was applied to CP 70-321 in April and May. Gross sugar yields of green cane were highest when Asulox was applied as a sequential treatment in both studies with yield increases of 3200 pounds/acre (78%) and 1800 pounds/acre (50%) over the weedy check being recorded for CP 65-357 and CP 70-321, respectively. Increases in sugar yield were also obtained in both studies when single applications of Asulox were made in April or May.

The Sugarcane Delphacid is Discovered in Louisiana

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The sugarcane delphacid, *Perkinsiella saccharicida* Kirkaldy, an exotic pest of sugarcane was discovered in Louisiana on October 19, 1994, in a sugarcane field approximately 58 km southeast of Lafayette, LA. Feeding by nymphs and adult oviposition cause some debilitation of the sugarcane plant, but of principal concern is its ability to vector Fiji disease. After initial discovery, the 20 sugarcane-producing parishes of Louisiana were surveyed during November 1994 to determine sugarcane delphacid field densities and geographic distribution. The sugarcane delphacid was found in 22 of the 60 fields sampled, and in 13 of 20 parishes surveyed. Counts of adults ranged from a low of zero to a high of 12 in a field surveyed in St. Mary Parish. Nymphs were found only in 7 parishes and, in general, were found in those parishes with correspondingly high adult numbers. The results of a spring 1995 survey will also be included.

The West Indian Cane Weevil, a New Pest of Sugarcane in Florida

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The West Indian cane weevil (WICW), *Metamasius hemipterus* (L.), was detected for the first time in the U.S. in Homestead, Florida in 1984. In September 1994, a heavy infestation of this weevil was observed on sugarcane cultivar CP 85-1382. This cultivar was released to growers in 1993 and its acreage is very small. All known locations of this cultivar were surveyed, and the weevil was found on 11 of 18 locations surveyed. One location had 32% of the stalks infested, and another had 21%. Damage is confined to the lower internodes. The inside of the stalks are hollowed out, causing stalks to lodge. Infested stalks (170) were split open, all stages of growth of the WICW were present, and their number/stalk ranged from 0-13, with a mean of 2.4 weevils; 86% were larvae. Glucose and fructose were higher, and sucrose was lower in infested cane than in non-infested cane. Stalk weight of infested cane was significantly lower than non-infested cane. A replicated test of 10 commercial sugarcane cultivars was evaluated for resistance/susceptibility to the weevil. Infestation ranged from 0-14% of the stalks infested, with CP 85-1382 being the most susceptible, followed by CP 80-1743 (12%); 4% was the mean over all cultivars. Since there is no known biological control organism, and insecticidal control does not look promising, plant resistance could offer the best control approach against this pest.

Evaluation of Parental Clones in Breeding for Ratoon Stunting Disease Resistance

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Clones selected for advancement in the Canal Point Cooperative Sugarcane Breeding Program have been inoculated with Ratoon Stunting Disease (RSD) in separate tests for the past three years. Size of plots and the number of replications vary according to selection stage (amount of seedcane available). The number of stalks sampled per clone varied from three (3) to twenty (20). Since these are preliminary RSD ratings, only the susceptible clones, which showed colonized vascular bundles (CVB) were discarded. Seven female parents (CP 70-1133; CP 89-2149; CP 84-1322; CP 85-1025; CP 89-2319; US 90-1025 and Co 285) in the CP 92 & 95 series with at least 10 progenies had no progeny discarded. There were six female parents (CP 76-1306; CP 86-1427; CP 86-1670; CP 87-1733; CP 85-1758, and US 88-1014) that had >20% of their progeny discarded and CP 76-1306 and CP 87-1733 had >40% of their progeny discarded. All male parents with >10 progeny had at least one clone discard for susceptibility. Among the 25 parents used as males and the four polycrosses, six clones (CP 80-1743, SP 70-

1143, Akoki 22, CP 85-1491, CP 88-2045, and CP 89-2178) had >20% of their progeny discarded for RSD susceptibility. The average number of CVB for male parents with >10 progeny ranged from 1.81 for CP 81-1238 to a high of 6.31 for CP 88-2045. For the female parents, the average number of CVB ranged from 1.05 for US 90-1025 to 7.84 for US 88-1014. We feel that these data, although preliminary, show evidence that we should be able to effectively breed for resistance to RSD.

Relationship Between Ratoon Stunting Disease Resistance and Disease Incidence of Sugarcane Cultivars in Commercial Fields.

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The purpose of this study was to determine ratoon stunting disease (RSD) ratings of sugarcane cultivars based on the number of colonized vascular bundles (CVB) and correlate to disease incidence. RSD resistance ratings were determined by determining the number of CVB of cultivars in commercial sugarcane fields surveyed that were planted with seedcane that had no history of heat treatment or phytosanitary practices to control RSD. Field incidence of RSD stalk infection correlated (r=0.87) to the number of CVB in 220 commercial fields surveyed. Resistant cultivars, CL 73-239 and CP 72-2086, that had averaged 0.03 and 0.15 CVB, respectively, had an average of 2.7 and 1.4% stalks infected in 9 and 28 commercial fields surveyed. In contrast, susceptible cultivars, CL 61-620 and CP 72-1210, that had averaged 11.8 and 7.6 CVB, respectively, averaged 99.2 and 92.7% stalk infection in 38 and 8 fields surveyed. The results indicate that RSD did not increase in resistant cultivars in Florida even though no heat treatments and phytosanitary practices were conducted.

Selection for Cold Tolerance in Sugarcane

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Improvement of cold tolerance for sugarcane would sustain stable productivity of this crop in cooler regions and prevent loss in the Everglades Agricultural Area following serious freezes. The breeding of sugarcane cultivars resistant to cold injury has been one of the major objectives of the work of the United States Department of Agriculture at Canal Point, Florida. Sugarcanes in both Florida and Louisiana are grown in relatively high latitude regions where temperatures periodically drop below freezing and can cause a serious damage to sugarcane crop. Cold injury can cause significant reduction in growth of young cane and deterioration in juice quality. Sugarcane cold tolerance may be divided into three categories: (1) the resistance of leaves and buds to frost injury under relatively light freeze temperatures (0 to -3.3°C); (2) the resistance of stalk to freezing and subsequent deterioration under moderate freeze temperatures (-3.9 to -5.6°C); and (3) the ability to restubble after severe winters (below -5.6°C). Categories 1 and 2 are more important than category 3 to the sugarcane production in Florida.

A group of selected clones derived from backcrosses of hybrids between commercial cane and *Saccaharum spontaneum* was used to evaluate their responses to low temperature stress under field conditions. The experiment was carried out at the University of Florida Institute of Food and Agricultural Sciences Agronomy Farm, Gainesville from 1992 to 1994. Measurements of cold tolerance were based on the estimates of the green leaf area after freezes. Stalk samples also were taken to measure fiber content and juice quality for determining their possible association with cold tolerance. The frequency distribution of cold tolerance ratings appeared to be normal among selected clones under relatively light freezes, but the frequency distribution was skewed toward higher cold tolerance rating. Resistance to cold injury was positively associated with percentage of fiber content under moderate freezes but not under light freezes. A significant interaction between clones and environments suggested that selection for cold tolerance has to be based on tests at several locations and/or for several years. Statistical evaluation of response of sugarcane to low temperature stress should improve the effectiveness of selection for cold tolerance in sugarcane. The difficulty of gene transfer from *S. spontaneum* to sugaracne during nobilization is well known. It appears that there is no exception for cold-tolerant genes. Recurrent selection for cold tolerance by using combined gene pools of *S. spontaneum* plus hardier commercial cultivars may be more effective strategy to prevent loss of cold tolerance genes in the course of backcrosses or nobilization. Also induction of chromosome breakage with physical and chemical mutagens to increase recombination in early backcross generations or nobilization should be explored.

TCP 87-3388, a New, Early Sugarcane Variety for Texas

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The sugarcane variety TCP 87-3388 is from a polycross with CP 70-321 made in Canal Point, FL, in 1982. The seed was germinated in 1983 at Houma, LA, followed by two years of selection there. It was brought to Texas in 1985. The outstanding characteristic of TCP 87-3388 is its early maturity; it is the most precocious variety tested that has commercial value. On its earliest harvest date (September 13th) it produced a theoretical recoverable sugar yield of 10.4% sugar per ton of cane. If sustained, this level of sugar would permit Texas to harvest ten days earlier than its earliest date (Sep. 22, 1993). Early sampling showed that sugar per ton of TCP 87-3388 is superior or equal to CP 70-321 and superior to NCo 310. These latter two varieties occupy 85% of the Texas cane area. Its ash content is low and fiber is normal. TCP 87-3388 appears to be more resistant to the cane borer (*Diatraea saccharalis* F.) and the rice borer (*Eoreuma loftini* Dyar) than NCo 310 and less resistant than CP 70-321. Test plots surveys show that TCP 87-3388 is resistant to sorghum mosaic (SCMV-H), sugarcane smut (*Ustilago scitaminea* Sydow), and sugarcane rust (*Puccinia melanocephala* H. Syd. and P. Syd.) under Texas conditions. TCP 87-3388 can be infected by ratoon stunting disease (*Clavibacter xyli xyli* Davis *et al*), but its reaction is unknown and heat treatment of seed cane is recommended. TCP 87-3388 occasionally shows symptoms of yellow leaf syndrome, a disorder of unknown etiology.

Engineering Sugarcane for Resistance to Sugarcane Mosaic Virus

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Sugarcane mosaic potyvirus is the most important virus disease affecting sugarcane production throughout the world. Of the various strains found in the US, strain H causes the most significant losses. The virus has been propagated on *Sorghum bicolor* cv. rio and purified. A 2.0 kb cloned cDNA containing the coat protein gene has been sequenced. Several chimeric constructs have been made by fusion of the coat protein gene between the maize ubiquitin promoter and the nopaline synthase terminator in a high copy number plasmid. These constructs are being used in biolistic co-transformation experiments using the *bar* gene as the selectable marker. Plants regenerated on media containing Ignite and screened for the presence of the coat protein gene, will then be challenged for resistance against strain H, and the closely related strains I and M.

The Effect of Shavers, Diggers and Rolling Cultivators on the Development and Yield of Sugarcane Stubble in Louisiana

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Field studies were conducted to determine the influence of stubble shavers, stubble diggers, and rolling tine cultivators on sugarcane stubble development, yield, weed control, row height, and water furrow depth. Implement treatments were tested during two stubble-crop cycles from 1990 through 1993 at two locations on Commerce silt loam (Fine-silty, mixed, nonacid, thermic Aeric Fluvaquent) near Welcome and Edgard, La. The successive use of a stubble shaver, alone or in combination with a stubble digger and/or rolling tine cultivator, generally caused greater yield loss in the second and third-stubble crops than in the first-stubble crop. In experiment 1, the shaver and shaver/digger treatments reduced the second and third-stubble sugar yield of CP 65-357 by an average of 24%. The shaver treatment increased the first-stubble sugar yield of CP 70-321 by 19%, but the second and third-stubble sugar yield was reduced by an average of 24%. The variety CP 74-383, known for it's stubbling ability, was not affected by the implement treatments until the shaver/digger treatment reduced the third-stubble sugar yield by 27%. In experiment 2, the shaver treatment increased the first-stubble sugar yield of CP 70-321 by 8%. However, the second and third-stubble sugar yield of CP 70-321 and CP 72-370 were reduced by the implement treatments an average of 17%. Reduced sugar yield was more often due to less cane yield than to less sugar content. Although the implement treatments enhanced spring weed control, the potential for injury may warrant alternative weed control measures in older stubble cane. The implement treatments increased the depth of stalk origin, but did not affect the stool depth or number of stalks per stool. While the implement treatments

restricted the upward progression of the row surface, differences in water furrow depth were difficult to interpret due to ruts in the field.

Effects of Soil Amendment with Organic Wastes on Pythium Root Rot of Sugarcane

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Stubble decline, a complex of factors causing reduced ratoon yields, is the most important constraint to sugarcane productivity and profitabilty in Louisiana. Pythium root rot has been shown to play a role in stubble decline. The objectives of our research were to evaluate the potential of amending soils with different organic wastes to suppress Pythium root rot and to identify the major biological and chemical properties of organic wastes which may contribute to root rot suppression. Plants of CP 70-321 were grown in the greenhouse in Pythium-infested field soils amended (20%, v/v) with composts derived from municipal solid waste (MSW), municipal yard waste (MYW), cotton gin trash (CGT), or various tree barks. Additional treatments included amendments with dried sewage sludge (SS) and well-rotted sugar mill filtercake (FC) (10%, v/v). The effects of amendments on root rot severity and plant growth were evaluated after 8 to 10 weeks. Measurements included root fresh weight, shoot dry weight, shoot number, and extent of root colonization by Pythium. In addition, the severity of lateral root rot and root system discoloration was ranked on a scale of one to four.

Sewage sludge, CGT and FC amendments consistently suppressed Pythium root rot and enhanced root and shoot growth. Results using MYW and tree bark composts were inconsistent. MSW compost had no effect or enhanced disease severity and reduced plant growth. All organic wastes enhanced microbial activity and increased organic matter and plant nutrient levels in amended field soils. Sewage sludge, FC and CGT had higher microbial activity levels, contained higher levels of P and total N, and had lower C:N ratios than the other organic wastes. The MSW compost used in this study contained high salt concentrations (1000-2000 mg/kg), which may explain the poor plant growth observed with this treatment. Beneficial effects of SS, FC and CGT on plant growth parameters did not appear to be due to enhanced plant nutrient levels. Plants grown in soils amended with steam-sterilized SS, FC and CGT contained comparable nutrient levels to those grown in soils amended with the corresponding nonsterile wastes, but plant growth was not increased. This finding and the observed reductions in root colonization by Pythium and root rot severity suggest that the beneficial effects of amending soils with some organic wastes are primarily due to suppression of root rot. Suppression appears to arise from biological factors present in some organic wastes rather than from the nutritional or physicial benefits obtained by adding these materials to soils.

Heritability of Resistance to Sugarcane Red Rot and the Effect of Environmental Stress on Disease Severity

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Heritability of resistance to sugarcane red rot, caused by *Colletotrichum falcatum*, was studied using ten progeny of 40 crosses and their 24 parental clones during 1992 and 1993. An inoculation method was used to evaluate resistance, in which stalks were inoculated in the center internode, held under controlled environmental conditions for six weeks, then assessed for disease development. The number of nodes passed by internode rot symptoms, the number of rotted nodes in each direction from the inoculation point, and the extent of rotting based on percent discoloration in the inoculated internode and four internodes on each side were recorded. An internode rot index was calculated based on the number of nodes passed and the average extent of internode rotting. Narrow-sense heritability estimates determined by mid-parent-offspring regression for the disease variables ranged from 0.18±0.04 to 0.32±0.06. Genetic gain in resistance, assuming a 10% selection intensity, ranged from 14 to 27% of the mean. The internode rot index provided the highest heritability estimate and the most potential genetic gain by selection. Broad-sense heritability estimates for both parents and offspring, determined by variance component analysis, was high with a single-year model, but it was very low with a combined-year model. The results indicate that genetic variation for red rot resistance is significantly affected by environmental conditions, and single year results for evaluation of disease resistance are not reliable. An additional problem that may have affected the heritability study was that high levels of resistance are rare in the current breeding population.

Field experiment results suggest that resistance to red rot is affected by drought stress at planting. Shoot counts in plots planted with stressed, inoculated stalks were reduced for each of seven cultivars in two experiments. Cultivars were variable in their response to drought stress alone. Poor drainage reduced shoot populations for each of three cultivars. Shoot populations were lowest in the stressed, inoculated treatment, but the additional reductions resulting from inoculation were not significant. Deficient oxygen levels did not occur at the soil depth where the stalks were planted. The results suggest that poor drainage affects red rot severity and plant cane stand establishment through an indirect effect on the root system.

Potential Use of Gramoxone Extra in Sugarcane

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Gramoxone Extra was evaluated in 1994 and 1995 for ryegrass control (*Lolium multiflorum* Lam.) and sugarcane response. Mid-February applications were made to ryegrass 6 to 20 inches tall prior to sugarcane emergence. In mid-March, ryegrass was approximately 30 inches tall and sugarcane was 2 to 12 inches. Ryegrass control ranged from 79 to 85% with Gramoxone Extra applied in mid-February at 1.5 pints/A, while 2 pints/A provided 80 to 93% control. Mid-March application of Gramoxone Extra at 2 pints/A controlled ryegrass 80 to 87%. Sencor, Sinbar, Atrazine, or Karmex applied in mid-March provided no more than 32% ryegrass control. In some cases control of ryegrass was increased when Atrazine or Karmex was tank mixed with Gramoxone Extra. Sugarcane shoot populations in early May following Gramoxone Extra application at 2 pints/A in February were 9 to 31% greater than when Atrazine or Karmex

was applied in March. Even so, application of Gramoxone Extra did not improve cane or sugar yields, probably due to the favorable early season growing conditions. Tolerance of CP 70-321 to Gramoxone Extra applied at 1 and 2 pints/A in mid-March or early April was evaluated in fields free of ryegrass. Early and late applications were made to sugarcane 12 and 24 inches tall, respectively. Although visual sugarcane injury 26 days following the April application of Gramoxone Extra was as high as 25%, it was not reflected in differences in sugarcane shoot populations and heights measured in late April, or cane and sugar yields. In our studies, removal of ryegrass and other winter weeds from sugarcane with Gramoxone Extra in the spring resulted in faster drying of fields, improved tillage, and earlier cane emergence. Additionally, elimination of weeds promoted better placement of soil applied herbicides and more efficient fertilizer utilization.

Studies are underway to evaluate combinations of Gramoxone Extra with Sencor or Sinbar applied in the spring for bermudagrass control. When Sencor or Sinbar was applied to emerged bermudagrass, control 2 weeks after application was no more than 51%. Addition of Gramoxone Extra increased control of bermudagrass to around 85%, but also increased sugarcane injury. The subsequent effect of these treatments on bermudagrass reinfestation, sugarcane stalk population, and yield will be determined. Additionally, Gramoxone Extra will be evaluated as a postemergence-directed treatment for bermudagrass control in the row middles after layby. Effective control of bermudagrass at this time may reduce the potential transport of bermudagrass in seed cane to clean fields and in harvested cane delivered to the mill.

Evaluation of Adjuvants with Roundup for Improved Johnsongrass Control and Rainfastness

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Field studies were conducted to evaluate rhizome johnsongrass [*Sorghum halepense* (L) Pers.] control with Roundup and various additives. Treatments containing Roundup D-Pak at 20 oz product/A plus additives were applied in 1993 to johnsongrass 41 to 75 inches tall with 15 to 20% seedhead emergence and in two studies in 1994 to plants in the vegetative stage 20 to 36 inches tall. Addition of Herbex (0.25% v/v), Break-Thru (0.25% v/v), or HM 9207A (0.5% v/v) alone or plus Quest (0.25% v/v) gave 64 to 74% control of johnsongrass 14 days after treatment (DAT). This level of johnsongrass control was greater than the 53% obtained with addition of Induce (1.0% v/v). Johnsongrass regrowth did not occur following topgrowth removal 14 DAT. In the first study conducted in 1994, all additives controlled johnsongrass 14 DAT at levels comparable to the Induce standard, 78%. In the second study, addition of DyneAmic, HM 9207A, or LI 700 (0.5% v/v), Activator 90 or Herbimax (1.0% v/v), Herbex, Break-Thru, or Silwet L-77 (0.125% v/v), or LI 700 plus ACA (0.5% + 1 oz/A) controlled johnsongrass 61 to 79%. This level of control was greater than the Induce standard that provided 50% control. Johnsongrass regrowth following application of Roundup plus all additives was equivalent and less than for the nontreated control. Simulated rainfall studies were conducted to evaluate rhizome johnsongrass control with Roundup and spray adjuvants under field conditions. Plots received either no rainfall or rainfall 15 or 60 min after herbicide application using a rainfall simulator delivering 0.5 inch of water in 15 min. Treatments in 1993 included Roundup D-Pak at 30 oz product/A plus Kinetic HV (0.25% v/v), LI 700 or DyneAmic (0.5% v/v), Induce or Activator 90 (1.0% v/v), or LI 700 plus ACA (1.0% v/v + 1 oz/A). In 1994, Roundup D-Pak was evaluated with Kinetic HV (0.25% v/v), Break-Thru (0.15% v/v), and Induce (1.0% v/v). Growth stage of rhizome johnsongrass both years was the same as described for the additive studies.

In 1993, johnsongrass control 14 DAT was similar regardless of additive used and was no greater than 62% when averaged across simulated rainfall timings. Johnsongrass control averaged across additives was 27 and 54% for the 15 and 60 min rainfall timings, respectively, which was less than for no rainfall (93%). Even though johnsongrass control ranged from 27 to 93%, regrowth did not occur following topgrowth removal. At the 15 min rainfall timing in 1994, johnsongrass control with Roundup D-Pak was greater with addition of Break-Thru (40%) than with Kinetic HV (31%), with both higher than Induce (19%). At the 60 min rainfall timing and no rainfall, similar johnsongrass control was observed among additives; highest control was observed for the no rainfall treatment (68 to 72%). Johnsongrass regrowth was equal for Roundup D-Pak plus Induce and Kinetic HV, and greater than that for Roundup D-Pak plus Break-Thru.

Runoff Losses of Pesticides as Affected by Management Practices for Sugarcane

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In this study, we quantified the movement of atrazine, sencor (metribuzin), and guthion (azinphosmethyl) in surface runoff and subsurface flow from sugarcane plots under different pesticide management practices. These data are necessary to quantify water quality benefits and effectiveness of best management practices (BMPs) on reducing nonpoint source pollutants from herbicide, and insecticide applications. The soil is a commerce silt loam (Aeric Fluvaquent, fine-silty, mixed, nonacid, thermic) which was planted to sugarcane variety CP70-321 in September 1992. Three types of chemical applications were carried out: a full broadcast (high treatment), a 36-inch band application (conventional or standard treatment), and a 24-inch band application (low treatment). The design consisted of a total of six plots (2 replications x three treatments) with each plot having 9 six-foot rows with a surrounding levee. At the lower end of each plot, a sump (6.5 ft in depth) was installed. In each sump, a water pump was connected to a flow meter to measure the volume of runoff outflow. An automatic water sampler was connected to each sump with collection triggered when runoff water was detected. Samples were subsequently analyzed for pesticides and nutrients. Cumulative amounts of chemical losses in runoff waters were highest for full broadcast (high treatment) and lowest for the 24-inch band treatment. Results also indicated that for the high treatment, atrazine concentrations were 600-700 ppb measured 6 days following applications. For the standard (conventional) treatment, these concentrations ranged from 120 to 140 ppb. The amounts of runoff losses represent some 10% loss of the atrazine applied for each treatment. For sencor, lower concentrations in the runoff were detected (20-60 ppb) along with lower commutative amounts in comparison to that for atrazine. Due to the limited rainfall amounts during 1993, no guthion runoff losses were detected. For 1994, the amounts of guthion losses in runoff waters were extremely small. These amounts represent a maximum of less than 0.1% loss of that applied. Moreover, rainfall distribution patterns and timing of application directly influenced the amount susceptible for runoff. For the low treatment where one guthion application was made, no guthion losses in runoff waters were detected.

Outfield Variety Tests: More Than Just Yields

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Through the cooperative effort of the American Sugar Cane League, the United States Department of Agriculture-Agricultural Research Service, and Louisiana State University Agricultural Center, the Louisiana Sugarcane Variety Development Program has provided sugarcane growers with superior varieties for nearly 70 years. Breeding strategies have focused on developing erect varieties with early sucrose accumulation, cold and pest resistance, stubbling ability, and general adaptation to the state's subtropical climate. Varieties are selected for their potential as commercial varieties or as breeding material within this recurrent selection program. The final stage of the program, outfield variety testing, is designed to evaluate candidate varieties across the major geographical areas of the sugarcane belt by comparing them to commercially grown check varieties. Because larger plots over more locations are used in outfield tests, more confident estimates of varietal performance can be made. At this stage, there is increased emphasis on adaptation to mechanical harvesting, resistance to natural populations of diseases and insects, and stubbling ability. Test procedures have been modified over the years to improve efficiency and provide results that ultimately form the basis for releasing candidate varieties to the Louisiana industry. Current test field procedures are presented in this paper. Yield data from the outfield tests compare favorably to industry yields and help in preparing variety recommendations. Test field results and/or observations can also be used to address industry concerns regarding crop rotation, harvesting efficiency, disease occurrence and spread, planting dates, herbicide tolerance and maturity patterns. Harvesting losses in adverse conditions are documented in this paper using outfield results as a standard for industry comparison. The numerous uses of the outfield results dictate that this stage of the Louisiana Sugarcane Variety Development Program be conducted in such a manner as to provide the maximum amount of useful data.

Diagnosis of Ratoon Stunting Disease of Sugarcane by PCR-Based Procedures.

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The sequences of the ribosomal RNA genes as well as the spacers regions between them have been shown to be useful for identification of different species of bacteria. The intergenic

transcribed spacer region (ITS) located between the 16S and 23S rRNA genes may provide unique sequences with a potential for detection and identification of closely related bacteria. After comparing the sequence of the spacer region between *Clavibacter xyli* subsp. *xyli* and a closely related species, two regions were found that may be suitable as amplification targets by PCR. Computer programs were used to select two sets of primers to amplify the regions. The specificity of the primers was tested against several plant pathogenic and saprophytic bacteria commonly found in nature. As a result, a 267 bp fragment was found to be common in phytopathogenic coryneform bacteria, but the bacteria were easily distinguished by a unique restriction pattern when the fragment was digested with the endonuclease *DdeI*. On the other hand, a 234 bp fragment was found to be specific for the four strains of *Clavibaoter xyli* subsp. *xyli* tested. These strains are representative of four different regions throughout the world including Florida.

Development of a PCR Assay for Diagnosis of Leaf Scald Disease of Sugarcane

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Xanthomonas albilineans, the causal agent of leaf scald disease, produces the phytotoxin, albicidin, which interferes with DNA replication in chloroplasts resulting in chlorosis of affected plant tissues. Albicidin is produced by all naturally occurring strains of *X. albilineans* and is unique to the pathogen; thus, the genes involved in albicidin production might provide a suitable target for a PCR-based diagnostic assay for leaf scald disease. We have cloned DNA fragments which complement albicidin production in isolates of the bacterium where albicidin production has been blocked by Tn5 mutagenesis. For development of PCR primers, an 832 bp subclone of one of these cloned DNA fragments was sequenced. Computer programs were then used to select candidate primer pairs from the sequence and evaluate their exclusivity with respect to other known DNA sequences. Two 19 base oligonucleotides were selected for further study as primers and commercially synthesized. In preliminary PCR tests with the oligonucleotides primers, the expected 664 bp DNA product was obtained for all five strains of the pathogen tested. The strains were representative of the two genetic types of *X. albilineans* presently known to occur in Florida.

Metadatabase Analysis Method for Identifying Factors Affecting Sugarcane Production

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Large metadatabases were constructed from industry data in the Barbados and from experimental data in Florida. Tree-based regression analysis was performed on both datasets to identify plant nutritional, soil, and environmental factors related to sugarcane yields. The objective in using this approach was to raise questions about expected responses to added fertilizer when taking into account factors affecting plant response. Leaf analysis, crop yields and environmental data from 2,853 site observations over the period of 1985-1990 were collected on commercial sugarcane crops in Barbados. Preplant soil test data and crop yields from 148 control plots were collected from experiments located in commercial fields across the Everglades Agricultural Area during 1983-1990. Yields were grouped (low through high) as they were related to specific soil, plant, and environmental conditions. The regression tree approach is a new explanatory tool, rather than a confirmatory tool, which describes yield boundary conditions.

Mineral Content Comparisons for South Florida Topsoil, Subsoil, and Bedrock

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Topsoil and subsoil samples were collected at ten sites in the Everglades Agricultural Area and analyzed for phosphorus, potassium, magnesium, calcium, sodium, and several micronutrients using the Mehlich I extraction. In addition, limestone samples were collected at each site from the surface of the bedrock which lies beneath the organic and sandy soils located south of Lake Okeechobee. Limestone samples were digested in hot acid and analyzed for the same minerals which were extracted from the soil samples. Sites were selected to represent a range of soil types where prior test results had also shown differences in the mineral content of the topsoil. Across all sites, the ratio of extractable topsoil and subsoil Ca/Mg was associated with the ratio of total Ca/Mg of the underlying bedrock in a linear fashion. Where marl was present at the soil/bedrock interface, its composition of extractable calcium and magnesium was similar to the limestone associated with it. Extractable iron in the soil and subsoil was found to vary among the sites with the highest values being found in a mineral soil where the bedrock iron content was also the highest. Levels of most other mineral components of the limestone bedrock were similar across all sites and could not be correlated with the corresponding soil and subsoil data. However, the results of the chemical analysis for these components indicate that they were present during the formation of the limestone layer.

Journal American Society of Sugar Cane Technologists, Vol. 16, 1996

Factors Influencing Plant-Cane Yields in Successively-Planted Sugarcane

Richard N. Raid, Christopher W. Deren, and George H. Snyder
University of Florida
Belle Glade, FL

Florida sugarcane growers use two general planting systems, fallow and successive, with successive planting becoming the preferred system during the course of the past decade. When measured over the lifetime of the crop, successive planting holds an economic return advantage over fallow planting, however, it has been demonstrated that plant-cane yields are frequently lower in successively planted fields than in those planted using the fallow system. Three factors were hypothesized as being influential with regards to these lower yields: soul moisture at time of planting, available nitrogen during early plant growth, and soil-borne microbial factors. Field investigations were established during the 1993-94 growing season to determine the relative level of influence of each factor. At three separate locations, the growth and subsequent yield of successively-planted cane was compared with that from fields following rice, fall sweet corn, and a long dry fallow period, respectively. In each instance, fields were immediately adjacent to one another and were planted on the same day. Attempts were made to establish two soil moisture levels and four nitrogen levels in the two different cropping systems at each location. Consisting of a 2 X 2 X 4 factorial design, each treatment was replicated six times. Additionally, in a separate experiment at each location, two different soil insecticide levels were established to measure the possible influence of soil insects or nematodes in the two respective cropping practices. A single cultivar, CP 72-2086, was utilized throughout these investigations. Results with respect to the influence of the various factors on stalk populations, stalk biomass, and sucrose are presented. Preliminary results indicate that the soil moisture at time of planting and nitrogen fertility factors were relatively insignificant with respect to explaining differences observed in sugarcane growth and yields between the two cropping practices. The implication that this has with regards to the importance of other soil factors, such as soil microbes and insects is also discussed.

Sugarcane Ratoon-Crop Yield Patterns to Optimize Profits

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LSU Agricultural Experiment Station
Baton Rouge, LA

Economic analysis of sugarcane production in Louisiana indicates that planting and associated fallowing expenses represent major costs to production. This motivates the LAES Sugarcane Variety Development Program to improve the number and the ratoon crop yields of its new cultivars. Net present value (NPV) from a multiyear crop cycle is the net economic return from a field discounted for inflation. General farm overhead expenses were not included. Given a crop cycle with a fixed number of years (typically four), the average sucrose yield of a variety is directly related to its NPV. Growers routinely decide to plowout or retain a cane field based on its projected yields in the second ratoon crop. Although he may profit from retaining the field, his maximum profit might be made by plowing out and replanting. To effectively make this decision, the projected second ratoon profits are compared to the average annualized value of net returns (AVNR) from a four-year crop cycle (fallow year, plant cane, first and second ratoon crop) for that cultivar. This value allows comparison of returns of crops cycles of different lengths. Assuming a fixed four-year crop cycle length, crop yield patterns of cultivars with the same average sugar yields did not significantly affect their profitability. Varietal data

from two crop cycles of outfield data collected from ten locations between 1991 and 1994 were analyzed to ascertain the profitability of nine commercial cultivars. Yield patterns were variable, but generally there was substantially more yield decline between the first and second ratoon crops than between the plant cane and first ratoon crop. The NPV ranged from $102/A for CP 70-321 to $237/A for LCP 85-384, with other varieties producing less than $150/A. Very strong variety by location interaction, however, suggested that optimum variety choices may vary with location. Comparison of known second ratoon yields and the average AVNR for each cultivar-location mean indicated that returns of CP 65-357, CP 70-321 and CP 72-370 would have been maximized by plowing out its second ratoon crop about 21% of the time, and then replanting. The plowout percentage decreased to about 16% for LCP 86-454, 12-14% for LHo 83-153, LCP 85-384 and LCP 82-089, 10% for CP 79-318, and 9% for HoCP 85-845. The ranking for AVNR for the four-year crop cycle length did not necessarily follow the percent plowout information suggesting the most profitable crop cycle may vary with cultivar and field. However, 85% to 95% of the time, a fixed four-year cycle was more profitable than a fixed three-year cycle for these cultivars in these tests. Break-even yields for a third ratoon crop were estimated, but third ratoon yield data is lacking to evaluate a five-year cycle.

MANUFACTURING ABSTRACTS

Emissions Control Design Criteria for Bagasse Fired Boilers

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Norcross, GA

In today's competitive marketplace, mills are constantly seeking ways to improve performance and efficiency of their boiler and power plant facilities while reducing emissions. Combustion and environmental control technology is changing so fast that it is difficult for mills to know when to upgrade existing equipment or to replace old technology with new. Efforts to analyze and characterize the impact of sources and emissions on human health and the environment has led to increasingly stringent environmental control legislation. The trend for the foreseeable future is for emission limits to continue downward as control technologies advance and more information becomes available on the cause, effect and control of various pollutants.This paper will focus on the many factors mills must consider when making the decision to retrofit existing facilities or replace them with new technology. This paper will also provide a general overview of the technologies available, and their impact on boiler emissions levels.

Automation of the Milling Plant

Eduardo Samour
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For many years, mill engineers have struggled to maximize the efficiency of their milling plants. They modify the key elements that have direct effect in successful operation like: cane preparation, mill construction and configuration, mill settings, hydraulic pressure, maceration and imbibition. All of these influence, to a greater or lesser degree, the final results of sucrose extraction and pol % bagasse. But there is a fundamental element which is left in the hands of the mill personnel and it has a tremendous impact in the overall results. This element is the actual operation of the milling train. During the 1994-95 crop at Sugar Cane Growers Cooperative of Florida, two mills were equipped to be operated by a programmable controller. The system was designed to maintain a preset flotation of the top roll, regardless of the grinding rate. This presents several advantages as follows:

- Allows the top roll to operate at the offset for which the tandem was designed, preventing unnecessary overload to the mill drives.
- Ensures that all the pressure from the top roll is applied to the cane passing through the mill. This guarantees better mill performance.
- The mill will always operate at the optimum speed for a given grinding rate. This prevents the operation at speeds higher than required, reducing premature wear of mill components.

Several features were tested with the control system, to reduce the risk of overloading the mill drives. This can lead, in the long run, to considerable savings. This system proved to be successful in controlling the operation of the two mills under test. And if we agree that by

eliminating the human error in the operation of the mill, better pol extraction will result: that translates into additional revenues. Then we must agree that investing in automation of the milling train can only make sense. I must point out, that automation is only one of the elements for a successful operation. The expertise of the mill engineer to select proper mill settings and his ability to establish proper operating parameters, are the basic elements for success. This is the third in a series of papers by the author, geared to improve the efficiency of cane feeding and grinding. This is only the beginning. The ultimate goal is to integrate all the mills in the tandem and automate the operation from the cane conveyors to the last mill, and beyond.

Sugar Mill Performance: Survey and Enhancement

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When it comes to evaluating a sugar mill with regard to performance only, a simple, inexpensive survey will suffice, which, as opposed to evaluations conducted in connection with expansion or modernization programs, does not involve big money implementing recommendations based on its proceedings. Before investing in additions to, or in sophisticated innovation of machinery, optimum performance must be ensured. When evaluating mill efficiency improvement projects, cost and benefit calculations must be based on the tuned-up efficiency of the mill, to prevent false estimates of benefits. It does not make sense to attempt to correct a problem adding something to the mill, if it can be corrected with maintenance, repairs, and a tune-up. Therefore, the first step of performance optimization is the assessment of the as-found performance. If the mill in question is operational, and grinds its cane crop after crop, chances are that machinery and equipment are basically there, and that no major components are terminally ill. As for performance, though, ANY SUGAR MILL WILL LIKELY BECOME MORE PROFITABLE WITH LITTLE OR NO ADDITIONAL EXPENDITURES, IF ADEQUATE OPERATION IS EMPHASIZED. The surveyor's work is, of course, the cornerstone of the plan, and must be comprehensive; yet, it must extricate crucial information from details which tend to obscure the main issues.

The plan is the corollary of the survey, and will naturally include a good repair job under proper supervision, focused on deficiencies, and the securement of sufficient spares, to guarantee timely operation. Since labor and parts are routinely allotted for mill repairs, no unusual expenditures will be incurred. Then, personnel requirements must be reviewed, so as to bring the manning table down to reasonable numbers, if excessive. Finally, if a well conceived plan is worked out, and then it is not followed, we might just as well have not bothered with a plan at all; therefore, in order for the plan to achieve its goals, it must have a built-in follow-up procedure to guarantee results, and to facilitate direction and control. Probably, for the sugar mill under consideration, every penny of its working capital is precious; a prudent, judicious, and selective commitment of the funds, allocating them conservatively where they are most likely to return profitable revenues is the key to success. The monies so invested in mill repairs will also probably, for once, be paid back a hundredfold.

Journal American Society of Sugar Cane Technologists, Vol. 16, 1996

The Calculation of Roll Torque in Sugarcane Crushing

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The torque required to turn a pair of mill rolls crushing sugarcane can be theoretically found to be:

$$t = hR(1 - \cos a) / a$$

where t is torque expressed in ft-lb/ft of roll, h is hydraulic loading, lb/ft of roll, R is radius, ft, and a is the feed angle, radians. Consequently, roll torque depends directly on mill size, represented here by roll radius, on the severity of crushing, represented by roll load, and, to a lesser extent, on crushing rate, represented by some function of the feed angle, or of the mat thickness, for that matter. It does not depend on roll speed, and therefore, once the sugar mill is set, it is a machine functioning at constant torque. This theory has been tested under factory conditions, and it holds fairly well. Some of the mills at S.C.G.C. of FL. had incidentally been rigged with a profusion of instruments, and a flow meter for 1993-94 harvest. It was then possible to measure all the variables that might affect roll torque, and use them in conjunction with the turbine manufacturer's curves to corroborate torque, calculating back from the horsepower. All gathered data, and torque calculations from the formula, and from the horsepower curves are presented, along with the derivation of the formula for torque.

Some innovative turbine and mill plots of torque vs. horsepower, and of torque vs. speed are presented as well. They are useful since the constant torque of the mill or turbine implicates a horizontal line parallel to the abscissa axes. Also, on the torque vs. speed plot, area under the torque line equals horsepower saved for given mill speed reductions. Results from this investigation, their discussion, and the conclusions drawn from the testing in practice of the theory behind the formula complete the paper.

Direct Production of White Sugar with Membrane Filtration: Concept, Experiment, ... Reality?

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Ultrafiltration and microfiltration of clarified juice with ceramic and polymeric membranes has now been proven technically and in some circumstances even economically feasible, to produce cane juice practically free of turbidity. Such juice can then be processed without danger of premature fouling with finer pore polymeric membranes to remove 90% or more of color. From the standpoint of sugar color, it is advantageous that the color bodies removed with membranes are those with higher molecular weights, as those are the ones known to have higher syrup→sugar transfer rate. Pilot scale tests are reviewed with ultrafiltration of clarified juice with ceramic ultrafiltration membranes, as well as decolorization of this ultrafiltered juice with polymeric nanofiltration membranes. The three respective syrups, i.e. a) conventional, b) from ultrafiltered juice and c) from ultrafiltered and declolorized juice were crystallized to produce sugar of conventional crystal size. The experience from and results of, these tests are presented

as is an assessment of the economics of the respective processes.

Cane Preparation, Mill Extraction and Bagasse Density

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Recent data for cane preparation (P. I.) and mill extraction for Louisiana sugar factories is presented. Data on both tandem and individual mill extraction, and the degree of preparation achieved through the tandem is presented. Preliminary data on the density of bagasse at various pressures for the bagasse leaving each mill in the tandem is presented.

Alternative Uses for Sucrose

Donal F. Day
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Sucrose, like oil, is a large volume commodity. New products that upgrade the value of raw sugar are not likely to utilize a major proportion of the domestic sucrose production. However, there are specialty markets for products made from sucrose that can yield significantly higher returns than sweetners. A small proportion of sucrose converted to such products could do much to offset any changes in the current domestic price structure for raw sugar. Several current and future alternative products that can be produced by fermentation from sucrose, as well as the status of current research in this area, will be presented.

Donnelly Chute Controls at Westfield Factory

Woody Betz
Betz Engineering Sales Co.
New Orleans, LA

Chip Savoie
Dugas and LeBlanc, Ltd.
Paincourtville, LA

In 1993, the Westfield Factory had individual mill control on the first, second, and fifth mill, which were controlled by PID loop controllers. This past grinding we installed a computer to control mills two, three, and four and we removed the PID controller from the second mill to another location in the factory. The theory was three fold:

1. Economic benefits
2. Mill communications
3. Experimentation

The mechanical and electrical installation, computer screen design and settings, and

operations were discussed. The following graphs were shown: mill speed, moisture % bagasse, pol % bagasse, and cumulative pol extraction.

Mill Improvement at Cora Texas

Gene Bouquet
Cora Texas Manufacturing Co., Inc.
White Castle, LA

The improvements made for the 1994 grinding season, which improved our grinding efficiency, is outlined with a brief description of each improvement, in this paper. A table comparing the results of the 1994 grinding season to the 1993 grinding season showing how these improvements helped Cora Texas is shown on an overhead. Also the changes which should improve Cora Texas' mill extraction for the 1995 grinding season are listed.

Processing of Sugarcane Rind into Textiles

John R. Collier, Billie J. Collier, and Maryoud M. Elsunni
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A process was developed for conversion of sugarcane rind to textile and geotextile products. It includes partial, directional delignification, and optional agitation and/or tumbling preceding washing and subsequent steam explosion steps. The ultimate fibers in sugarcane rind are similar to those of hard wood, 2 to 5 mm long; however, to form geotextile mats or spin yarns, the fiber bundles used should be at least 2.5 cm long. A sugarcane crushing process causes the length of bagasse segments to be too short; therefore, this conversion process starts with a separation similar to that referred to as the "Tilby Process". The cane is split longitudinally in two halves, the high sucrose content pith routed out, and the resulting rind used for this process. The typical treatment in this process is to react 0.1 N NaOH at 166°C (steam pressure 620 kPa) with the rind segments in a reactor designed to perform specific mechanical actions. The wet and partially delignified fiber bundles can be damaged by complete rotatory action of an impeller in the reactor; therefore, either an oscillating agitation and/or tumbling of the reactor around its horizonal axis is employed. In this paper all runs included tumbling and some feature agitation also. Since the rind is encouraged to split longitudinally rather than transversely by the mechanical action, lignin is removed preferentially in the longitudinal direction. As a result bundles of fibers from the rind are successively reduced in cross section with slight reduction in length, thereby yielding the necessary length and desired cross section for conversion to textile and geotextile products.

Studies to Minimize Carryover in Sugarcane Boilers

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Nalco Chemical Co.
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The carryover of boiler water into the steam lines can cause a variety of problems in sugar mills. These problems range from heat and efficiency loss to deposit on turbines and evaporators to erosion of steam lines. Many steps have been taken over the years to minimize the effect of this carryover. The problem, however, remains and exists to some extent in nearly every mill.Boiler operating conditions are known to have a substantial affect on the actual level of carryover. A new patented diagnostic tracer was used to provide on-line monitoring of carryover levels in a local mill. These levels were tracked through changing boiler operating conditions to study the effects of those changes. This paper reviews and explains the main factors contributing to carryover. It reviews the setup of the studies conducted this year and documents the results with recommendations for future operating procedures and testing.

Evaporation Process Energy Balance in the Fabrication of Sugarcane

Carmen Y. Baez
Romilio Alvarez
Blas Marin
Sugar Cane Growers Cooperative of Florida
Belle Glade, FL

The performance and capacity of existing evaporator systems under actual operating conditions are the main focus of most engineers in the fabrication process since rarely a practicing engineer has to design completely new evaporators for an assumed set of conditions.The intent of this paper is to present the basic calculations in determining evaporator heat transmission and heat balace calculations in the sugar cane fabrication process. Regardless of use, design, or operation, the same basic heat balances are calculated. For the purpose of this presentation, an existing system will be evaluated against original design and modified for added capacity or thermal economy.

HEAT TRANSFER:

Evaporation in any evaporator, single or multiple effect, is dependent on the transfer or transmission of heat from a hot condensing vapor through tube walls to a cooler boiling liquid. The relationship is characterized by the equation:

$$Q = U\ A\ \Delta T$$

Where: Q = quanity of heat transferred (BTU/hr)
U = overall heat transfer coefficient (BTU/hr(F)-(ft^2)
A = effective heat transfer area (ft^2)
ΔT = Temperature difference between steam and boiling liquid (°F)

HEAT BALANCE CALCULATIONS:

Process steam consumption will be calculated for every heating and evaporation requirement with the corresponding heat balances. These can be summarized as:

1. Heating of limed juice
2. Heating of clarified juice
3. Juice concentration in evaporators
4. Boiling of massecuites

The above calculations will be presented in a user-interactive computer program, which

will allow the audience to troubleshoot their individual process performance according to their own needs, and in case of added capacity, will determine the requirements to accomplish such a task.

Analytical Instrumentation in Raw Sugar Production

Stephen J. Clarke
Flo-Sun Sugar Company
Okeelanta Corporation
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The number of instrumental techniques available to raw sugar producers has increased significantly in recent years. At present most are more suitable for research applications but some have become routine in such areas as cane and raw sugar quality determination. This paper includes a summary of our recent work in the areas of turbidimetric, spectrophotometric and x-ray fluorescence techniques.

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS EDITORIAL POLICY

Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

Frequency of publication:

The Journal will appear at least once a year. At the direction of the Joint Executive Committee, the Journal may appear more frequently. Contributed papers not presented at a meeting may be reviewed, edited, and published if the editorial criteria are met.

Editorial Committee:

The Editorial Committee shall be composed of the Managing Editor, Technical Editor for the Agricultural Section, and Technical Editor for the Manufacturing Section. The Editorial Committee shall regulate the Journal content and assure its quality. It is charged with the authority necessary to achieve these goals. The Editorial Committee shall determine broad policy. Each editor will serve for three years; and may at the Joint Executive Committee's discretion, serve beyond the expiration of his or her term.

Handling of manuscripts:

Four copies of each manuscript are initially submitted to the Managing Editor. Manuscripts received by the Managing Editor will be assigned a registration number determined serially by the date of receipt. The Managing Editor writes to the one who submitted the paper to inform the author of the receipt of the paper and the registration number which must be used in all correspondence regarding it.

The Technical Editors obtain at least two reviews for each paper from qualified persons. The identities of reviewers must not be revealed to each other nor to the author during the review process. Instructions sent with the papers emphasize the necessity for promptness as well as thoroughness in making the review. Page charges will be assessed for the entire manuscript for non-members. Members will be assessed for those pages in excess of ten (10) double spaced Times New Roman (TT) 12 pt typed pages of 8 1/2" x 11" dimension with one (1) inch margins.

When a paper is returned by reviewers, the Technical Editor evaluates the paper and the recommendations of the reviewers. If the paper as received is recommended by two reviewers for publication in the Journal, it is sent to the Managing Editor. At this time, the Managing Editor will request a final version in hardcopy and on diskette in WordPerfect format from the corresponding author.

If major revisions are recommended, the Technical Editor sends the paper to the author for this purpose, along with anonymous copies of reviewers' recommendations. When the paper is returned to the Technical Editor, he/she will judge the adequacy of the revision and may send the paper back to any reviewer for further review. When the paper has been revised satisfactorily, it is sent to the Managing Editor for publishing. A paper sent to its author for revision and held more than 6 months will be given a new date of receipt when returned. This date will determine the priority of publication of the paper.

A paper rejected by one reviewer may be sent to additional reviewers until two reviewers either accept or reject the paper. If a paper is judged by two or more reviewers as not acceptable for the Journal, theTechnical Editor returns it to the author along with a summary of the reasons given by the reviewers for the rejection. The registration form for the paper is filled out and returned to the Managing Editor along with copies of the reviewers' statements and a copy of the Technical Editor's transmittal letter to the author. The names of all reviewers must be shown on the registration form transmitted to the Managing Editor.

After the review process is completed, each accepted paper is read by the Technical Editor to correct typographical, grammatical, and style errors and to improve the writing where this seems possible and appropriate, with special care not to change the meaning. Instructions for the printer are inserted as needed. The papers are sent by the Technical Editor to the Managing Editor who notifies the authors of this fact and of the probable dates of publication.

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The paper is printed in the proper form for reproduction, and proofs are sent to the authors for final review. When the proofs are returned, all necessary corrections are made prior to reproduction. The author will be notified at the appropriate time to order reprints at cost.

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RULES FOR PREPARING PAPERS TO BE PRINTED IN THE JOURNAL OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

Format

Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION (OR RESULTS AND DISCUSSION), CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized. Scientific names shall be italicized.

All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. If using WordPerfect, set the bottom margin at 0.5 inches. This will set the page number at 0.5 inches and the final line of text at 1 inch from the bottom margin. Exactness in reproduction can be insured if electronic copies of the final versions of manuscripts are submitted. Authors are encouraged to contact the managing editor for specifics regarding software and formatting software to achieve ease of electronic transfer.

Authorship

Name of the authors, institution or organization with which they are associated, and their locations should follow the title of the paper.

Abstract

The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

Tables

Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Use TAB function rather than SPACE BAR to separate columns of a table.

Figures

Number the figures consecutively and refer to them in the text as Figure 1, Figure 2, etc. Each figure must have a legend. Figures must be of sufficient quality to reproduce legibly.

Drawings & Photographs

Drawings and photographs must be provided separately from the text of the manuscript and identified on the back of each. Type figure numbers and legends on separate pieces of paper with proper identification. Drawings and photographs should be of sufficient quality that they will reproduce legibly.

Reference Citations

The heading for the literature cited should be REFERENCES. References should be arranged such that the literature cited will be numbered consecutively and placed in alphabetical order according to the surname of the senior author. In the text, references to literature cited should be made by name of author(s) and year of publication from list of references. Do not use capital letters in the titles of such articles except in initial words and proper names, but capitalize words in the titles of the periodicals or books.

Format Example

ITCHGRASS *(ROTTBOELLIA COCHINCHINENSIS)* CONTROL IN SUGARCANE WITH POSTEMERGENCE HERBICIDES

Reed J. Lencse and James L. Griffin
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and

Edward P. Richard, Jr.
Sugarcane Research Unit, USDA-ARS, Houma, LA 70361

ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

RESULTS AND DISCUSSION

Table 1. Visual itchgrass control and sugarcane injury as influenced by over-the-top herbicide application at Maringouin and Thibodaux, LA, 1989.

CONCLUSIONS

ACKNOWLEDGMENTS

REFERENCES

GUIDELINES FOR PREPARING PAPERS FOR JOURNAL OF ASSCT

The following guidelines for WordPerfect software are intended to facilitate the production of this journal. Authors are strongly encouraged to prepare their final manuscripts with WordPerfect 5.2 for Windows or WordPerfect 6.0 for Windows or Dos. Please contact the Managing Editor if you will not use one of those software packages.

Paper & Margins: All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. To achieve this with WordPerfect, set the top, left, and right margins at one inch. However, set the bottom margin at o.5 inches. This will place the page number at 0.5 inches and the final line of text at one inch.

Fonts: Submit your document in the Times New Roman (TT) 12pt font. If you do not have this font, contact the Managing Editor.

Alignment: Choose the full alignment option to prepare your manuscript. The use of SPACE BAR for alignment is not acceptable. As a general rule SPACE BAR should only be used for space between words and limited other uses. Do not use space bar to indent paragraphs, align and indent columns, or create tables.

Do not use hard returns at the end of sentences within a paragraph. Hard returns are to be used when ending paragraphs or producing a short line.

Place tables and figures within the text where you wish them to appear. Otherwise, all tables and figures will appear after your References section.

Styles: ***Italicize*** scientific names. Do not use underline.

Tables: Use Tab stops or WordPerfect's Tables feature when typing tables. Avoid the space bar to separate columns (see alignment). If you do not use WordPerfect's Tables feature, use the **Graphics** line draw option. This can be used to place lines precisely on the page. All lines should begin with the left most symbol in their left most column and should end with the right most symbol in their right most column.

Citations: When producing Literature Citations, use the indent feature to produce text as below.

1. Smith, I. M., H. P. Jones, C. W. Doe, 1991. The use of multidiscipline approaches to control rodent populations in plants. Journal of American Society of Plant Management. 10:383-394.

CONSTITUTION OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

As Revised and Approved on June 21, 1991
As Amended on June 23, 1994
As Amended on June 15, 1995

ARTICLE I

Name, Object and Domicile

Section 1. The name of this Society shall be the American Society of Sugar Cane Technologists.

Section 2. The object of this society shall be the general study of the sugar industry in all its various branches and the dissemination of information to the members of the organization through meetings and publications.

Section 3. The domicile of the Society shall be at the office of the General Secretary-Treasurer (as described in Article IV, Section 1).

ARTICLE II

Divisions

The Society shall be composed of two divisions, the Louisiana Division and the Florida Division. Each division shall have its separate membership roster and separate officers and committees. Voting rights of active and honorary members shall be restricted to their respective divisions, except at the general annual and special meetings of the entire Society, hereinafter provided for, at which general meetings active and honorary members of both divisions shall have the right to vote. Officers and committee members shall be members of and serve the respective divisions from which elected or selected, except the General Secretary-Treasurer who shall serve the entire Society.

ARTICLE III

Membership and Dues

Section 1. There shall be five classes of members: Active, Associate, Honorary, Off-shore or Foreign, and Supporting.

Section 2. Active members shall be individuals residing in the continental United States actually engaged in the production of sugar cane or the manufacture of cane sugar, or research or education pertaining to the industry, including employees of any corporation, firm or other organization which is so engaged.

Section 3. Associate members shall be individuals not actively engaged in the production of sugar cane or the manufacture of cane sugar or research pertaining to the industry, but who may be interested in the objects of the Society.

Section 4. Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to 5 living Honorary members assigned to the two Divisions jointly.

Section 5. Off-shore or foreign members shall be individuals not residing in the continental United States who may be interested in the objects of the Society.

Section 6. Supporting members shall be persons engaged in the manufacturing, production or distribution of equipment or supplies used in conjunction with production of sugar cane or cane sugar, or any corporation, firm or other organization engaged in the production of sugar cane or the manufacture of cane sugar, who may be interested in the objects of the Society.

Section 7. Applicants for new membership shall make written application to the Secretary-Treasurer of the respective divisions, endorsed by two members of the division, and such applications shall be acted upon by the division membership committee.

Section 8. Minimum charge for annual dues shall be as follows:

Active Membership	$10.00
Associate Membership	$25.00
Honorary Membership	NONE
Off-shore or Foreign Membership	$20.00
Supporting Membership	$50.00

Each Division can assess charges for dues more than the above schedule as determined by the Division officers or by the membership at the discretion of the officers of each Division.

Amended 6/23/94 Article 111, Membership and Dues, Sections 8.

Dues for each calendar year shall be paid not later than 3 months prior to the annual meeting of the member's division. New members shall pay the full amount of dues, irrespective of when they join. Any changes in dues will become effective in the subsequent calendar year.

Section 9. Dues shall be collected by each of the Division's Secretary-Treasurer from the members in their respective divisions. Unless and until changed by action of the Joint Executive Committee, 50 percent of the minimum charge for annual dues, as described in Section 8 for each membership class, shall be transmitted to the office of the General Secretary-Treasurer.

Section 10. Members in arrears for dues for more than a year will be dropped from membership after thirty days notice to this effect from the Secretary-Treasurer. Members thus dropped may be reinstated only after payment of back dues and assessments.

Section 11. Only active members of the Society whose dues are not in arrears and honorary members shall have the privilege of voting and holding office. Only members (all classes) shall have the privilege of speaking at meetings of the Society.

ARTICLE IV

General Secretary-Treasurer and Joint Executive Committee

Section 1. The General Secretary-Treasurer shall serve as Chief Administrative Officer of the Society and shall coordinate the activities of the divisions and the sections. He or she will serve as ex-officio Chairperson of the Joint Executive Committee and as General Chairperson of the General Society Meetings, and shall have such other duties as may be delegated to him or her by the Joint Executive Committee. The office of the General Secretary-Treasurer shall be the domicile of the Society.

Section 2. The Joint Executive Committee shall be composed of the elected members of the two division Executive Committees, and is vested with full authority to conduct the business and affairs of the Society.

Amended 6/23/94 Article III, Membership and Dues, Sections 9.

ARTICLE V

Division Officers and Executive Committee

Section 1. The officers of each division of the Society shall be: a President, a First Vice-President, a Second Vice-President, a Secretary-Treasurer or a Secretary and a Treasurer, and an Executive Committee composed of these officers and four other members, one from each section of the Division (as described in Section 3 of Article VII), one elected at large, and the President of the previous Executive Committee who shall serve as an Ex-Officio member of the Division Executive Committee. The office of the Secretary-Treasurer in this constitution indicates either the Secretary-Treasurer, or the Secretary and the Treasurer.

Section 2. These officers, except Secretary-Treasurer, shall be nominated by a nominating committee and voted upon before the annual division meeting. Notices of such nominations shall be mailed to each member at least one month before such meeting. Ballots not received before the annually specified date will not be counted.

Section 3. The Secretary-Treasurer shall be appointed by and serve as a non-voting member at the pleasure of the Division Executive Committee. The Secretary-Treasurer may not hold an elected office on the Executive Committee.

Section 4. The duties of these officers shall be such as usually pertain to such officers in similar societies.

Section 5. Each section as described in Article VII shall be represented in the offices of the

President and Vice-President.

Section 6. The President, First Vice-President, and Second Vice-President of each Division shall not hold the same office for two consecutive years. Either Section Chairperson (as described in Section 3 of Article VII) may hold the same office for up to two consecutive years. The terms of the other officers shall be unlimited.

Section 7. The President shall be elected each year alternately from the two sections hereinafter provided for. In any given year, the Presidents of the two Divisions shall be nominated and elected from different sections. The President from the Louisiana Division for the year beginning February, 1970, shall be nominated and elected from the Agricultural Section. The president from the Florida Division for the year beginning February, 1970, shall be nominated and elected from the Manufacturing Section.

Section 8. Vacancies occurring between meetings shall be filled by the Division Executive Committee.

Section 9. The terms "year" and "consecutive year" as used in Articles V and VI shall be considered to be comprised of the elapsed time between one annual division meeting of the Society and the following annual division meeting of the Society.

ARTICLE VI

Division Committees

Section 1. The President of each division shall appoint a committee of three to serve as a Membership Committee. It will be the duty of this committee to pass upon applications for membership in the division and report to the Secretary-Treasurer.

Section 2. The President of each division shall appoint each year a committee of three to serve as a Nominating Committee. It will be the duty of the Secretary-Treasurer of the Division to notify all active and honorary members of the Division as to the personnel of this committee. It will be the duty of this committee to receive nominations and to prepare a list of nominees and mail this to each member of the Division at least a month before the annual meeting.

ARTICLE VII

Sections

Section 1. There shall be two sections of each Division, to be designated as:

1. Agricultural
2. Manufacturing

Section 2. Each active member shall designate whether he or she desires to be enrolled in the Agricultural Section or the Manufacturing Section.

Section 3. There shall be a Chairperson for each section of each Division who will be the member from that Section elected to the Executive Committee. It will be the duty of the Chairperson of a section to arrange the program for the annual Division meeting.

Section 4. The Executive Committee of each Division is empowered to elect one of their own number or to appoint another person to handle the details of printing, proof reading, etc., in connection with these programs and to authorize the Secretary-Treasurer to make whatever payments may be necessary for same.

ARTICLE VIII

Meetings

Section 1. The annual General Meeting of the members of the Society shall be held in June each year on a date and at a place to be determined, from time to time, by the Joint Executive Committee. At all meetings of the two Divisions of the Society, five percent of the active members shall constitute a quorum. The program for the annual meeting of the Society shall be arranged by the General Secretary-Treasurer in collaboration with the Joint Executive Committee.

Section 2. The annual meeting of the Louisiana Division shall be held in February of each year, at such time as the Executive Committee of the Division shall decide. The annual meeting of the Florida Division shall be held in September or October of each year, at such time as the Executive Committee of that Division shall decide. Special meetings of a Division may be called by the Executive Committee of such Division.

Section 3. Special meetings of a Section for the discussion of matters of particular interest to that Section may be called by the President upon request from the respective Chairperson of a Section.

Section 4. At Division meetings, 10 percent of the active division members and the President or a Vice-President shall constitute a quorum.

ARTICLE IX

Management

Section 1. The conduct and management of the affairs of the Society and of the Divisions including the direction of work of its special committees, shall be in the hands of the Joint Executive Committee and Division Executive Committees, respectively.

Section 2. The Joint Executive Committee shall represent this Society in conferences with the American Sugar Cane League, the Florida Sugar Cane League, or any other association, and may make any rules or conduct any business not in conflict with this Constitution.

Section 3. Four members of the Division Executive Committee shall constitute a quorum. The President, or in his or her absence one of the Vice-Presidents, shall chair this committee.

Section 4. Two members of each Division Executive Committee shall constitute a quorum of all members of the Joint Executive Committee. Each member of the Joint Executive Committee, except the General Secretary-Treasurer, shall be entitled to one vote on all matters voted upon by the Joint Executive Committee. In case of a tie vote, the General Secretary-Treasurer shall cast the deciding vote.

ARTICLE X

Publications

Section 1. The name of the official journal of the Society shall be the "Journal of the American Society of Sugar Cane Technologists." This Journal shall be published at least once per calendar year. All articles, whether volunteered or invited, shall be subject to review as described in Section 4 of Article X.

Section 2. The Managing Editor of the Journal of the American Society of Sugar Cane Technologists shall be a member of either the Florida or Louisiana Divisions; however, he or she shall not be a member of both Divisions. The Division affiliation of Managing Editors shall alternate between the Divisions from term to term with the normal term being three years, unless the Division responsible for nominating the new Managing Editor reports that it has no suitable candidate. The Managing Editor shall be appointed by the Joint Executive Committee no later than 6 months prior to the beginning of his or her term. A term will coincide with the date of the annual Joint Meeting of the Society. No one shall serve two consecutive terms unless there is no suitable candidate from either Division willing to replace the current Managing Editor. If the Managing Editor serves less than one year of his or her three-year term, another candidate is nominated by the same Division, approved by the other Division, and appointed by the General Secretary-Treasurer to a full three-year term. If the appointed Managing Editor serves more than one year but less than the full three-year term, the Technical Editor from the same Division will fill the unexpired term of the departed Managing Editor. In the event that the Technical Editor declines the nomination, the General Secretary-Treasurer will appoint a Managing Editor from the same Division to serve the unexpired term.

Section 3. The "Journal of the American Society of Sugar Cane Technologists" shall have two Technical Editors, which are an Agricultural Editor and a Manufacturing Editor. The Managing Editor shall appoint the Technical Editors for terms not to exceed his or her term of office. Any Technical Editor shall be a member of either the Louisiana or Florida Division. Each Division will be represented by one technical editor at all times unless the Executive Committee of one Division and the Managing Editor agree that there is no suitable candidate willing to serve from that Division.

Section 4. Any member or nonmember wishing to contribute to the Journal of the American Society of Sugar Cane Technologists shall submit his or her manuscript to the Managing Editor. The Managing Editor shall then assign the manuscript to the appropriate Technical Editor. The Technical Editor shall solicit peer reviews until, in the opinion of the Technical Editor, two responsible reviews have been obtained that either accept (with or without major or minor revision) or reject the manuscript. For articles accepted with major revision, it shall be the responsibility of the Technical Editor to decide if the authors have satisfactorily completed the major revision(s). The Technical Editor may solicit the opinion of the reviewers when making this decision. The Technical Editors shall not divulge the identity of any reviewer. The Managing Editor shall serve as Technical Editor of any manuscript which includes a Technical Editor as an author.

ARTICLE XI

Amendments

Section 1. Amendments to this Constitution may be made only at the annual meeting of the Society or at a special meeting of the Society. Written notices of such proposed amendments, accompanied by the signature of at least twenty (20) active or honorary members must be given to the General Secretary-Treasurer at least thirty (30) days before the date of the meeting, and he or she must notify each member of the proposed amendment before the date of the meeting.

ARTICLE XII

Dissolution

Section 1. All members must receive notification from the General Secretary-Treasurer of any meeting called for the purpose of terminating the Society at least thirty (30) days prior to the date of the meeting. After all members have been properly notified, this organization may be terminated at any time, at any regular or special meeting called for that purpose, by an affirmative vote of two-thirds of the total honorary and active members in good standing present at the meeting. Thereupon, the organization shall be dissolved by such legal proceedings as are provided by law. Upon dissolution of the Joint Society, its assets will be divided equally between the two Divisions of the Society. Dissolution of the Joint Society will not be cause for automatic dissolution of either Division. Upon dissolution of either Division, its assets will be divided in accordance with the wishes of its members and in conformity with existing IRS regulations and other laws applicable at the time of dissolution.

ARTICLE XIII

Assets

Section 1. No member shall have any vested right, interest or privilege of, in, or to the assets, functions, affairs or franchises of the organization; nor any right, interest or privilege which may be transferable or inheritable.

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Volume 17
Florida and Louisiana Divisions
June, 1997

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ASSCT

1996 JOINT EXECUTIVE COMMITTEE
AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

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EDITORS
Journal American Society of Sugar Cane Technologists
Volume 17
June, 1997

Managing Editor:
Barry Glaz

Agricultural Editor
Christopher W. Deren

Manufacturing Editor
Benjamin Legendre

PROGRAM CHAIRMAN
26th Annual Joint Meeting
American Society of Sugar Cane Technologists
J. D. Miller

Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to 5 living Honorary members assigned to the two Divisions jointly. (Article III, Section 4 of the Constitution of the American Society of Sugar Cane Technologists).

Following is the list of the living Honorary members of the American Society of Sugar Cane Technologists for Florida and Louisiana Divisions:

Florida Division

Guillermo Aleman
Henry J. Andreis
Enrique Arias
Antonio Arvesu
D.W. Beardsley
John B. Boy
Horace Godfrey
Arthur Kirstein III
William J. Miller, Jr.
Joseph Orsenigo
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Les A. Edye, Margaret A. Clarke, and Jane A. Kitchar. Effects of Treatment of Syrups with a New Dextranase (*Chaetomium gracile*).

M. S. Irey, L.E. Baucum, K.S. Derrick, B.E. Lockhart, and K.L. Manjunath. Incidence of the Lutevirus Associated with Yellow Leaf Syndrome in Florida Commercial Varieties.

B.L. Legendre, M.A. Godshall, and X.M. Miranda. Contribution of Field Soil and Cane Trash to Sugarcane Juice Color

W.H. White. Revisiting Crop Loss to Sugarcane Borer

A Message from the Managing Editor

This is the sixth ASSCT journal on which I have served as an editor. Beginning six years ago, I served on three journals as the Agricultural Editor and I have served as the Managing Editor of the three most recent journals. I thank ASSCT for allowing me to serve in these capacities. I thank Dr. Fred Martin for his guidance as he served as Managing Editor while I was the Agricultural Editor. I also thank Drs. Stephen Clarke, Christopher Deren, Ben Legendre, and Richard Raid for facilitating my work by exemplary performance of their duties as Agricultural and Manufacturing Editors while I was Managing Editor.

I felt obligated to leave some brief advice to future editors, reviewers, and authors of the Journal of the American Society of Sugar Cane Technologists.

Editors

Most authors who submit manuscripts do so because they feel they have important technical information to share with other scientists. Also, it is often important for authors to know about the review status of their manuscripts quickly. Many authors use these manuscripts as documentation to their employers of the high quality of their work. As editors, you have certain fundamental responsibilities. You must choose reviewers with the appropriate technical training to judge the merits of manuscripts. You must ultimately decide whether a reviewer's decision is valid. And very importantly, you must accomplish all of this quickly. Try to return all reviews to authors within two months, and if a review must take longer, contact the author to apologize and explain the delay.

Reviewers

Consider it an honor that an editor has chosen you to review the technical merits of a manuscript submitted to this journal. If you know you cannot review the manuscript by the stated deadline, then inform the editor. Otherwise, review the manuscript thoroughly and promptly. Seek the advice of others if there are points about which you are unsure. Take extra care in all of your comments to treat authors with respect and courtesy. If a manuscript must be rejected, provide valid reasons.

Authors

When preparing your final diskette version of the manuscript, pay close attention to the ASSCT Journal guidelines. Use the most recently published journal as a guide. Pay close attention to what is in bold, italics, and capitals, and review the line spacing and other format requirements. After three years as Managing Editor, my preference is to work with tables constructed with WordPerfect's graphic line draw and spaced only with tab settings, no spacebars. Tables imported from spreadsheets or constructed with the WordPerfect tables feature usually require a great deal of reformatting. When ASSCT began accepting manuscripts electronically, we chose WordPerfect as our word processor. All authors should go to great lengths to use WordPerfect for ASSCT manuscripts and to submit manuscripts in the version of WordPerfect requested by the Managing Editor. Many subtle changes occur to manuscripts even when created on the same version of the same word processor, presumably because the editor uses a different printer than the author. This is particularly true of tables imported from spreadsheets. Manuscripts submitted in a different word processor require much extra work from the Managing Editor.

Many of our potential authors do not submit full manuscripts, but are eligible to submit abstracts of their presentations at our joint meetings. These abstracts are not peer reviewed. I began a new policy with abstracts this year. If an author did not submit a diskette version of his or her abstract, then the abstract was not included in the journal. If you do not have WordPerfect, an ASCII version of an abstract will normally be acceptable.

Once again, I thank the Society for allowing me the opportunity to serve as an editor of its journal. I hope the readers have found many useful and well written articles in the journal, and I hope they find the format agreeable.

Barry Glaz
Managing Editor,
Journal of American Society of Sugar Cane Technologists,
Volumes 15, 16, and 17

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PRESIDENT'S MESSAGE
FLORIDA DIVISION

Luis R. Zarraluqui
Sugar Cane Growers' Cooperative of Florida

Good morning everyone. On behalf of the Florida Division of the American Society of Sugar Cane Technologists (ASSCT) we welcome the Louisiana Division to the 26th Annual Joint Meeting, hoping the preparations and the program will make your attendance as pleasant as we wish it to be. Thank you very much for your presence.

Under normal circumstances we would be reporting production figures of sugarcane, sugar and molasses for the last Florida crop. Circumstances at present are, however, anything but normal, and we will use this opportunity to convey our concerns to you, in view of the bleak future our industry faces.

John Stuart Mill wrote: "When society requires to be rebuilt, there is no use in attempting to rebuild it on the old plan." Globalism is the road to a New World Order, and we are all, undoubtedly, marching down that road or, for that matter, rebuilding society whether we like it or not. What will be the role, if any, of our cane sugar industry in the new play?

Cane sugar is under fire in the US right now, and it would appear its downfall is just a matter of time, besieged by far too many foes, whom we can all pinpoint. To further complicate matters, our business suffers an ever-diminishing productivity which drives production costs endlessly up, spurred on by the four horsemen of modern economic apocalypse: legislation, regulation, taxation, and inflation. This low productivity is about to take its toll, and IT IS IMPERATIVE TO INCREASE PRODUCTIVITY IF WE ARE TO KEEP FIGHTING FOR SURVIVAL IN THE YEARS TO COME.

Six main reasons are allegedly getting our cane sugar industry into perilous grounds. While some are true and, unquestionably, ammunition for our detractors, others may just be allegations that have no merit. The issue here is not their merit, though; the fact is they are being brandished against the industry, thereby creating public opinion:

1. The pollution of air and water in which the cane sugar industry is engaged.

2. The gradual erosion of the vegetable layer of the EAA, perhaps accelerated by machine harvesting.

3. The billion-plus dollar annual subvention in the form of price support, afforded US producers by the Sugar Program, as part of the Farm Bill.

4. The US free trade agreements, i.e., the GATT, the World Trade Organization, and specifically those with American sugar producing countries, such as NAFTA.

5. The inevitable urban development of Florida sugar country, in response to relentless growth of south Florida population, and

6. The imminent reinsertion of Cuba in the American marketplace, and its subsequent membership in the NAFTA .

While we cannot help the eventual upcoming of the 2nd., 5th., and 6th reasons, and can do little, if anything about the 1st and 4th, we can and must take action to make this business profitable per se. Perhaps this is our last chance to come up with a viable solution for the economics of the industry, and perhaps the seriousness of the present situation is what it takes for the interested parties to trigger that action. An old Cuban proverb, much in vogue of late, may very well summarize our predicament: "Lo bueno que tiene esto es lo malo que se está poniendo", that is, "The good this has is the bad it is getting".

THE WORLD IS CHANGING

Modern Homo Sapiens appeared on the face of the earth some 500 generations ago. During the first 350 (about 25,000 years), human beings used to live in caves, hunting and barely surviving. During the last 70, they started communicating in writing; during the last 6 they printed; during the last 4, they learned to measure time with precision; during the last 2, the electric motor was invented, and in generation 500, ours, 99 % of all inventions, discoveries, improvements and innovations we enjoy today were made, one half of them in the last 15 years. Life is changing so fast, that fictions of yesterday are the truths of today.

The US economy is changing along with the world. It is turning from an industrial and manufacturing type into a service type economy. We have witnessed the decay or demise of the smokestack industry, the auto makers, and the transportation industry, and at the same time, the proliferation of service activities such as banking, insurance, accounting, advertising, telecommunications, and so forth.

Under such conditions, changing technology is critical to an organization's survival, yet it does not guarantee success. In discussing technological change, it is helpful to understand the concept of a PARADIGM CHANGE, a concept that was originally applied to technical issues by Thomas Khun in his book **The Structure of Scientific Revolutions**. When there is a paradigm change, an entire way of thinking about a subject goes out the window, to be replaced by a new way of thinking about it. The US is in the midst of a dramatic, yet often unappreciated change in its economic basis. The US industrial-based economy has been declining for decades, being replaced by a service-based economy. We are spectators of an economic paradigm change which has been in progress since World War II, and is still accelerating.

Based on legislation affecting the profitability of industrial activity, and on the proclivity of the US to globalism, underscored by trade agreements, it is easy to infer that our country is engaged in an effort to export smokestack, textile, and related industries, and import clean, cheaper, finished products, whether they are steel shapes, automobiles, machinery, apparel, footwear, or for that matter, sugar. Congress has been extremely prolific in the enactment of federal legislation during the last quarter of the century: CRA, ADEA, OSHA, ERISA, TEFRA, DEFRA, COBRA, OBRA, WARNA, ADA, FMLA, just to mention some. Our legislators have taken over the function of trade unions in improving fairness, quality, compensation, and security of employment on one hand, and have been redistributing wealth on the other through copious legislation, and have overdone it, driving costs unnecessarily high, and productivity unreasonably low.

Government, which at the same time is busily regulating air and water quality, has imposed stringent controls over emissions and effluents from industrial installations, enacting regulatory behemoths (the Clean Air Act, and its offspring, the EPA and the DER), whose meddling in the operation of factories has financially crippled US producers, many of them on a permanent basis.

WAS PROTECTIONISM AN ANSWER?

While the rules of the game will likely change in the years ahead, protectionist legislation had been the rule since the New Deal. Lockheed, Penn Central, Chrysler, and many more have faced economic failure, and all have applied for subsidies from the government. Congress offered loan guarantees, tax reductions, price supports, and outright grants in order to keep businesses on the line.

The US government supported sugar producers in periods of low prices since 1934, first thru the US Sugar Act which expired in 1974, and then reinstated a Sugar Program as part of the 1981 Agricultural and Food Act. The program supports the price of domestic sugar by a rather complex mechanism combining forfeiture provisory loans, tariffs, and import quotas. Therefore, sugar has been insulated from foreign competition. But, what would happen should that protectionist policy be abandoned? What is happening to the rest of US industries, specifically those with low productivity?

The deregulation of railroads and truckers by Congress under the Motor Carrier Act sent both into turmoil, leaving them free to fail, as they were forced to offer shippers more efficient service at lower rates, competition intensifying to an unprecedented degree, and bankruptcy soaring. It translated into 20% of the International Brotherhood of Teamsters driver-members laid-off on one side, and into Congress-created Amtrak and Conrail deficit operations, on the other. Airlines did not fare any better, either; fresh in our memories are still the fates of Eastern, Pan-Am, US Air, United Airways, and Braniff.

The US Steel industry is history. The huge Bessemer converters which made our country the world's leading steel producer and exporter, are now lifeless cyclopes standing as centerpieces of outdoor museums of artifacts along the Monongahela River.

The automobile industry, on the contrary, fought back. In the late seventies and early eighties, Chrysler went into a state of virtual bankruptcy, with Ford not far behind. They, as well as all other US auto makers have endeavored to survive, engineering their own paradigm change to introduce new technology. The industry has become a High-Tech one. High-Tech is a mélange of computer electronics, software, robotics, communications equipment, computer-aided design and manufacture, and laser technology. The auto industry was born again from 1978 thru 1985 with more than half of the domestic auto plants rebuilt, and 7 % annual average productivity improvement, for an impressive 50 % for the period. Notwithstanding, in 1992 General Motors announced the closing of 14 plants, and the relocation of some of them south of the border. In the light of such developments, we must conclude that High-Tech has not been enough, and the increase in productivity must be pursued much further.

Other technological innovations, aided by computers, are so nearly self-regulated, that an entire factory may be kept running by a few people operating sets of controls. This method of production, called AUTOMATION, is bringing about economic changes far larger than those resulting from the industrial revolution. Automation is the only hope of our economic system. James Baker, Executive Vice-President of General Electric Co. has said: "Industry must automate, emigrate, or evaporate. If it automates within the next 10 or 15 years, there will undoubtedly be a tremendous loss of jobs. If it doesn't, there won't be any jobs at all in those industries some day."

Regarding wage schemes, there have also been innovations. Longstanding wage patterns are being broken sharply in settlements between employers and unions, in an attempt to compensate for nosediving productivity, for example:

- wage cuts negotiated with the unions by Eastern, in exchange for a stake in the ailing airline,

- innovative labor contracts without pay raises, such as American Airlines',
- linkage of wages to company profitability, doing away with automatic raises for inflation,
- going back to piecework rate,
- requirement for the workers to invest part of their earnings in the company, substituting stock ownership and profit-sharing for guaranteed wage and benefit increases, and
- two-tier wage and benefit schemes for newly hired and veteran employees,

are some of the innovations that have been resorted to, and are now in force in contracts covering airline, food store, electrical, copper, and aerospace workers. With one exception, all these innovative compensation patterns haven't worked, because they still go with the trend in which American life is immersed at present. They are solely putting off the final outcome, (Eastern's, for instance), and are therefore, dismal failures.

The exception is the piecework rate. It marks the revival of individual incentive, and the gains for the company are lowered costs, better utilization of facilities, and improved worker morale, with earnings proportional to individual skill and effort; for the worker, individual recognition, and the opportunity to control the level of his standard of living by his own initiative. But piecework in our case must only be used should the nature of the job not be compatible with contract maintenance, which would be the solution of choice. That will not only cut labor expenses, but will also do away with the administrative worries. What the sugar mill will need in the 21st century, when just the fittest will survive, is nothing but expert, skillful, strictly professional handling of mill maintenance.

THE OMEGA APPROACH

After the lessons, difficulties and fate of all those who have gone before, what we must now decide is how much of this scenario applies to us today. What is going to turn things around? How long will lobbying work? Shall we merely hang on while it does.... if it does?

Labor, and labor-related expenses for sugar mill departments are, at present, anywhere from 2 to 5 times the expenses incurred for parts and supplies, depending on which department. That ratio must be reversed if we wish to survive. To that end, we are proposing our approach to the problem of staying in business by the turn of the millennium. We call it THE OMEGA APPROACH, as it is the last solution available at the moment, and therefore our last hope. However, it deals only with the factory, the industrial end of the operation. Naturally, our colleagues from agriculture, transportation, and administration must come up with corresponding measures to improve productivity in those areas. Otherwise, our efforts at the factory alone, wouldn't do any good:

1 Automate, in order to run the mill with only a handful of people, who would be almost as few as present supervisory personnel. Australians have walked a long way in that direction, and should world sugar price fall to $ 0.06/lb, they would still operate at a profit. They are the source for reference.

2 Increase capacity without increasing amount of equipment, or even better, reducing it.

3 Concentrate, using fewer units having large capacity, rather than many small units: one large

milling tandem instead of two smaller ones; one or two boilers instead of four or five, and so forth.

4 Simplify, reduce moving parts to a minimum, and get rid of redundant equipment. Reduce wear resorting to space-era materials.

5 Phase out batch equipment, in favor of continuous equipment, easier to man, and to automate.

6 Eliminate overhead: buy only finished replacement parts ready to go in place, which do not require further fabrication and/or machining.

7 Rationalize expenditures; for maintenance purposes, divide equipment into dynamic and static. Allot repair money for dynamic equipment in the ratio of 7 to 10 times the allotment for static equipment.

8 Invest every possible penny that will translate into labor savings.

9 Do not tinker with mill repairs; leave them to the professionals. Contract slack season annual repair jobs and crop maintenance on a turn-key basis.

10 Use piecework rate for those jobs which cannot be contracted.

The foregoing are sound economic measures that will reduce operation cost to a minimum, and have been proven extensively elsewhere. They, along with a paradigm change required to double our present harvest size, and to spread it into a 10 or 11 month-a-year operation, would shape us up to fight the battle to come. That paradigm change will be, of course, an agricultural endeavor.

We are not crying wolf. Every business that has undergone prolonged periods of low productivity, has seen its operation end the same way: with an economic collapse. It is now our turn, and the handwriting on the wall is as distinct and as ominous as on King Belshazzar's wall. But it is not our intention to speculate how we will be doing ten years from now should our industry survive that long. Forecasts are outside the province of this message.

We must gird to bite the bullet, running the race to automation, and time is of the essence. No one starting this race right now will regret it five years down the road; if we lose, we won't be that far behind where we are now, but if we win, our future will be worth the effort. We must act at once, and act decisively. Anyhow, Damon Runyon's inescapable logic will forever apply: "The race is not always to the swift nor the battle to the strong, but that's the way to bet."

We wish you all the best of luck. Thank you very much.

PRESIDENT'S MESSAGE
LOUISIANA DIVISION

Ronald Gonsoulin
Ulysse Gonsoulin & Sons, Inc.

I would like to express my sincere thanks and offer a warm welcome to my fellow members and guests of the American Society of Sugar Cane Technologists. To those of you from the Louisiana division, hello again, and a special thanks to the Florida division for hosting the Twenty-Sixth Annual Joint Meeting in St. Petersburg, Florida.

Our family farm has been in sugar production for four generations. The most important factor, but the least controllable, is the weather. I don't remember what normal weather is. Always unpredictable, but nevertheless, we all accept the challenges or we would not be agriculturalists.

In the last five years, we have had normal weather starting with the 8° freeze in December of 1989 which devastated the 1990 crop. In 1991, we had excessive rains. In 1992, the crop was torn apart by Hurricane Andrew. In 1993, we had a drought. The year 1994, on average, was a respectable year; and in 1995, some areas had a bumper crop, while others were somewhat dry.

I would like to summarize the harvest for the 1995 Louisiana crop. I will also comment on the 1995 Farm Bill and its impact upon our direction, Cuba and its possible role in the industry, and the 200th anniversary of Commercial sugar production in South Louisiana.

The 1995 harvest season began at most mills on September 28 and ended January 3rd, making this a 98-day grinding season. However, the average for all the Louisiana mills was only 79 days. Frequent heavy rains were part of the conditions, but it was not a cold winter harvest. During the season, 10,585,417 gross tons of sugarcane were delivered to 19 factories. We have only one other factory that processes syrup, but it does not grind sugarcane. There were 395,000 acres of sugarcane grown, of which 31,000 were used for seed cane. About 364,000 acres were harvested for commercial sugar production. The estimated sugar production is approximately 1,075,000 tons, raw value. The total acres of sugarcane for harvest and the gross tons processed are new records for the Louisiana sugar industry. This is the first time Louisiana has ever ground over 10 million tons, and only the second year the state has ever produced over 1 million tons of sugar. Production from molasses was about 61 million gallons, also a record.

On a per acre basis, Louisiana produced about 29.1 tons of sugarcane per acre and 5910 pounds of sugar per acre. The production of tons per acre was among the ten highest, while the production of sugar was a new state record, breaking earlier records of 5835 pounds set in 1988 and 5878 in 1989. Preliminary calculations of pounds of sugar per ton cane are estimated to be 203 pounds. Molasses production is estimated to be about 5.8 gallons per ton of sugarcane, which is somewhat high, reflecting the harvesting of immature canes earlier in the season.

On weather this past year: the summer was drier than normal, allowing much fallow work to be done without rain problems. However, this carried over into the harvest and reduced yields for some growers in the western and northern areas. The winter we experienced was more normal than the past five years, although November and December were wet. There have not been any freezes in the cane area to cause problems since the December freeze of 1989. We have had relatively mild winters. That is not the case for the beginning of the 1996 crop, as we have experienced several freezes with the 20° and below temperatures. As of this writing, there are estimates of between 20 and 30 percent crop damage, with the northern areas being the hardest hit. Also in 1995, we had a close encounter with Hurricane Opal in early October as it traveled northeast through the Gulf of Mexico, striking the panhandle of Florida near Destin. It caused some lodged cane, but not twisted. We are extremely fortunate we did not experience the 140 mph winds. We received about 2 inches of rain from this system. Because it was dry at the time, muddy conditions lasted only a short while.

At present, the Louisiana sugar industry is going through a harvesting change. We had at least seven combine harvesters operating in 1995. This transition started several years ago when a small syrup mill, located on the western edge of the growing area, transitioned from hand cleaning to more economical means. This led the operator to a combine, keeping in mind he did not want to burn sugar cane. Today, several have harvested without burning, only to give in to increased delivery schedules which prompted them to burn.

We have enough two-row whole-stalk harvesters at present to cut 100 percent of the Louisiana crop. We also have most operators who operate independent of one another, which I think is uneconomical and extremely capital intensive.

I express these facts because we need to think much further ahead in time to plan a better, less capital intensive approach. Whole-stick harvesters have not been fully optimized. Due to this, our variety program has only recently given us a high tonnage cane. Only a few growers have harvested this cane and quite a number of farms is considering moving to the combine system. This will facilitate a two-system type of mill yard handling required. We need to be most cautious in the direction we move because it reflects costs to all mills and growers affected. I believe the Florida industry can assist us with information and advice in this area.

We in the sugar industry must stay mindful of our soil type, rainfall, row profile, and the fact that we cannot stop harvesting because of rain and mud. Our goal should always be the most sugar for the least cost within the confines of environmental guidelines. The economic health of the individual farm is the ultimate concern.

Commodity agriculture is low margin, and producers and processors will operate at low costs and high volume. The question will be how the profits are divided between producers and processors.

One of the most crucial aspects of our business is dependent upon a group of people who do the research, to whom I would like to say thank you. We need your help to make the most of our resources and remain a viable industry, a total team effort. I again thank those of you who give us your efforts in this business.

One farming factor is the relationship that some foster with Cuba. It is with caution that I mention this because the role that country will play, if any, is very ill defined. It was at one time a major player in the sugar markets.

Another concern is that of the 1995 Farm Bill and its impact over the next seven years. This was one of the most contentious Farm Bill debates in history. The U.S. sugar industry finds itself facing many Republican mandated reforms, including a switch to recourse loans and a one-cent forfeiture penalty. These elements greatly increase the risk under which we operate now and into the future. Despite these reforms, there are members of Congress on both sides who feel the program should be eliminated. The U.S. sugar industry is facing opposition from the big industrial users, the environmentalists, and the free traders of both parties--all of whom overlook the reforms made thus far.

The new Farm Bill essentially ends 60 years of government involvement in agriculture, and was heralded by House Agriculture Committee Chairman, Pat Roberts, as "the boldest farm proposal ever to pass the Congress."

The House gave approval after narrowly defeating attempts to kill the sugar and peanut programs. The two major opponents of the program, Representatives Chuck Schumer and Dan Miller, offered amendments to reduce loan guarantees to 12 cents and increase assessments by 25 percent. The Bill was defeated by a vote of 217 to 208. Our foes are multi-billion dollar corporations that have aligned themselves with national environmental groups with the Florida Everglades as a focal issue. Also, good government groups have been fooled into believing the sugar industry costs the American taxpayers money. It is a good feeling to know there are still a majority of rational people in Washington who understand the difference between profitability for some and survival for others.

We must now look to the future, not just for two or five years, but to the next generation of sugar growers. We need to move from our traditional way of operating and look for opportunities to move the future into our own hands, not those of others, particularly not the refiners and commercial users. We now know that the refiners who have been a necessary part of our business are not necessarily our friends. When it comes to the survival of our industry, we need to view the future in a business perspective, not that of an emotional or a personal viewpoint.

It is hoped that the latest legislation will give us seven years to position ourselves more efficiently and be highly competitive--second to none. I hope we have the good fortune to keep this program intact. We should interpret this as an opportunity, rather than an obstacle. If we get another Farm Bill in seven years, we can count on a loan rate reduction to be one of the first items discussed.

In 1995, Louisiana celebrated 200 years of commercial production of sugar. During this time, the industry withstood many disasters such as floods, droughts, hurricanes, diseases, wars, too much government, and not enough government. We have survived and I have extreme confidence in our industry, whether it be sugar cane or sugar beets. We are resilient, and I have confidence in our ability to overcome these adversities. Change is unavoidable, it is the nature of life. But sustainability must be our driving force.

MESSAGE FROM THE 1997 EXECUTIVE COMMITTEE FLORIDA DIVISION

SUGARCANE AND THE EVERGLADES A GOOD RELATIONSHIP SCIENCE CAN IMPROVE

Our organization agrees with many diverse groups that an effective long-term plan is needed to save the natural Everglades. Sugarcane farming in the Everglades Agricultural Area (EAA) and a sustainable Everglades should not be viewed as two opposing forces. The two are inextricably linked; conceptually, a sustainable agriculture in the EAA and a sustainable Everglades ecosystem are interdependent. We recognize that both the natural Everglades and the farmers in the EAA face many challenges to become both compatible and sustainable in the future.

FACTS ABOUT THE FLORIDA SUGAR INDUSTRY

Background

Sugarcane is a grass grown primarily for its sugar (sucrose) content. This field crop has been grown commercially in southern Florida since the 1920s and is one of the most economically important crops in the state. Approximately 425,000 acres are grown annually, primarily around the lower half of Lake Okeechobee. The proximity to the lake is important in that it offers some cold protection to the tender cane during occasional harsh winter weather.

Sugarcane, most suitable for the EAA

Sugarcane planting and harvesting operations are conducted during the fall and winter. This period is typically dryer than the summer months. Thus, sugarcane culture is in harmony with the South Florida climate. The cool, dry fall and winter months are good for plant emergence and mature sugarcane ripening.

Once established, sugarcane is far more water tolerant than leafy vegetables or sweet corn. This becomes an asset for summer water management practices. Area farms store water during surplus rainfall periods by maintaining higher water tables in sugarcane fields, flooding vacant vegetable and sugarcane fields, or growing paddy rice. This good soil conservation practice is also a very effective best management practice for phosphorus reduction.

Water that is managed by area farmers is monitored for quantity and quality, and reports are submitted to the South Florida Water Management District monthly. All farmers have responded well under regulatory action and made commendable gains in the management of this valuable and essential resource. EAA farms have achieved a 71% across the board reduction in phosphorus levels in the water discharged from the EAA according to a recent report from the South Florida Water Management District. This reduction exceeds the 25% annual goal required for the entire EAA basin by Florida's Everglades Forever Act.

Sugarcane uses fertilizer efficiently

Sugarcane requires only one-half the amount of phosphorus needed for sweet corn, one third the amount needed for celery, and only one quarter the amount needed for lettuce. Sugarcane, like any other plant, requires nutrients for optimum growth. In the EAA, nutrients are provided for plant uptake from rainfall, irrigation water, the organic soils, and supplemental fertilizer. Research by the University of Florida to determine adequate supplemental levels of nutrients necessary for sugarcane production began in 1929. Early research showed that the high levels of phosphorus needed for vegetable production reduced the amount of sugar in the cane stalk. Since then, numerous research studies based on yield responses have established the guidelines currently used for fertilizer rates.

Research studies by Coale et al. (Agronomy Journal 85:310-315) showed that sugarcane biomass removes more phosphorus from the soil than the amount applied as fertilizer. This indicates that the sugarcane plant uses not only fertilizer phosphorus but also residual and naturally occurring phosphorus. Izuno et al. (Agricultural Best Management Practices (BMPs) for Phosphorus Loading Reduction in the Everglades Agricultural Area (EAA), IFAS, Univ. of Florida, 11/29/90) showed that less phosphorus was found in drainage water from fertilized sugarcane fields than in drainage water from adjacent non-fertilized fallow fields.

Rotation: A nutrient, soil conservation, and pest management tool

Sugarcane is planted in rotation with rice, sod, spring and fall sweet corn, radishes, and other assorted vegetables. To maximize the efficient use of plant nutrients in the soil, a rotation from higher to lower fertility-requiring crops is normally practiced. A typical production plan would be for a sweet corn or a vegetable crop (9 months to several years) to be followed by one or two sugarcane crops (3-8 years). These would be followed by a summer rice crop. This rotation not only maximizes the use of residual fertilizer, but also follows a decreasing intensity of drainage and pest management requirements.

Sugarcane in Florida receives relatively low amounts of pesticides

For several reasons, sugarcane in Florida requires a minimum amount of pesticides. First, sugarcane is relatively tolerant to damage by most pest species. This is especially true with respect to pests which attack foliage. Taking advantage of this tolerance, sugarcane growers have successfully implemented natural control strategies for most pests.

For control of plant diseases, no fungicides (pesticides used specifically for pathogens) are applied by sugarcane growers in Florida. Resistant sugarcane varieties are the single-most important management strategy for the control of bacterial, fungal, and viral diseases. Natural control of insect pests through the preservation and encouragement of parasitoids and predators is recognized as an important tenet of integrated pest management (IPM). For insects and mite pests of sugarcane, biological control (using predators, parasites, and other beneficial organisms to control pests) has been an outstanding management strategy.

Insect parasites are among the most valuable biological control agents, but several other common predators are also important. These include earwigs, lacewings, lady beetles, fire ants, and ground beetles, as well as birds such as the cattle egret. Years of cooperative research by private industry, the USDA, and the University of Florida have been conducted to boost biological controls. One large sugarcane company has developed a system for growing beneficial insects and releasing them as a substitute for pesticides to control one of the most important insect pests.

While EPA-approved insecticides may occasionally be required, the use of chemicals in Florida sugarcane is best described as limited. For example, recent estimates indicated that more than 80% of the sugarcane in Florida is often grown without receiving a single foliar pesticide application for insects, mites, or diseases over the course of a year.

EAA ambient air monitoring

The Palm Beach County Health Department and the Florida sugar industry have conducted programs of air quality monitoring in the EAA since the late 1960s. These programs are designed to monitor particulate matter, sulfur dioxide, and ozone under sampling protocol and regulations of the EPA and the Florida Department of Environmental Regulation. Air quality in the EAA is well within state and federal air quality standards and is comparable to both the statewide and coastal Palm Beach County averages. Palm Beach County Health Department measurements show that less than 2% of the airborne particulate matter measured at their five monitoring stations is from agricultural origins.

Public and private groups work to sustain agriculture

Public and private sugarcane genetics programs have focused on sugarcane cultivars with high yields and disease resistance. Cultivars originating in the EAA have substantially improved sugar production in Florida, Louisiana, Texas, Latin America, and other regions throughout the world.

Geneticists and agronomists are currently broadening their programs to seek cultivars that are even more phosphorus efficient and are more tolerant to high water tables. The phosphorus research is two-pronged; isolate the ability to achieve high yields with less phosphorus fertilizer, and select for the ability to remove more phosphorus from the soil. Research and commercial conditions in the EAA, and other countries, have shown that sugarcane tolerates short-term floods, and that this characteristic could be genetically improved. More water-tolerant sugarcane would have side benefits of enhancing soil conservation efforts and further reduce the phosphorus in EAA drainage water.

At the factories

In Florida, the sugar mills process approximately 17,000,000 tons of sugarcane, from which about 1,750,000 tons of raw sugar and about 90,000,000 gallons of black strap molasses are produced each year. Raw sugar is used by refineries to produce refined sugar. Chemically classified as a carbohydrate, sugar is a natural energy source. Black strap molasses is normally used for cattle feed or as a feed-stock in the production of alcohol, a renewable fuel.

The production of sugar from cane involves several well established processes; extraction, clarification, evaporation, crystallization, and mechanical separation. **None of these processes involve the use of hazardous or environmentally undesirable materials.** Current emphasis in the industry is towards improved process control and efficiency.

At the grinding station, juice is extracted by crushing the cane through a series of three or four roll mills. The fiber residue left from grinding the cane, bagasse, is sent to the boilers as fuel. Using bagasse as the renewable fuel makes Florida sugarcane processing operations almost energy self sufficient.

With the modern boilers now in use, the sugar industry produces a surplus of energy, available as electric power to domestic and industrial users. Flue gas generated during boiler operations has a higher moisture content because the bagasse itself is a moist material. This helps produce a very clean stack gas which is in compliance with all local and federal clean air laws. Fuel biomass, bagasse, is almost entirely plant material. This ash can be used as fertilizer due to its high mineral content. Once these materials have been returned to the cane field, a natural cycle is completed.

Clarification of the juice is normally carried out with the help of lime and heat in cylindrical tanks. Clarified juice and a precipitate are obtained. This insoluble precipitate, comprised of field soil and plant material, is filtered out and retained in ponds for eventual return to production fields. Again, this completes a natural cycle. The clarified juice is concentrated in evaporators and seeded with fine sugar powder to serve as nuclei for the sugar crystals. Finally, the crystals, raw sugar, are separated from their surrounding molasses by centrifugal force and sent to storage or to cane sugar refineries.

Quality control in the Florida sugar industry is state of the art

The United States cane sugar industry has much more regulatory control than most foreign suppliers of sugar. These regulations impact many aspects of operations, including cane production, construction of new equipment and facilities, worker safety, and the environment. If rationally conceived and implemented, such ordinances are desirable for the industry to be a good citizen and neighbor. Compared to many overseas milling operations, our mill technologists have successfully created a safe and environmentally compatible industry.

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SUGARCANE RESPONSES TO N FERTILIZER APPLICATION ON CLAY SOILS

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ABSTRACT

Sugarcane fertilization practices have been developed for the Rio Grande Valley of Texas based on numerous studies; however, few have been conducted on clay soils. Nitrogen has been found to be the primary nutrient needed, and responses to N fertilization have been limited in the plant-cane crop and increase incrementally in succeeding ratoons to its highest level in the second and following ratoons. This study was conducted to evaluate the effect of rate and timing of N fertilizer application on sugarcane growth, and to determine optimum fertilization practices for sugarcane yield on clay soils. As in previous studies, responses to N application did not occur in the plant cane crop, but were observed in the first through third ratoons. Increasing rate of N application improved stalk population, stalk growth rate, leaf area index, cane yield and sugar yield. Early N application resulted in depletion of available N before full growth potential had been reached, possibly to microbial immobilization or leaching. Late fertilizer application caused a loss of early growth, an effect that was mostly, but not entirely, compensated for by later growth. Soil NO_3^--N levels varied little even though yield responses to N fertilization indicated that there were some dramatic differences in soil N availability and residual levels. Increasing N application had detrimental effects on sugarcane juice quality, but the magnitude of the effects were small compared to increasing cane growth responses, therefore sugar yield continued to increase as N application increased. Early fertilizer application resulted in lower sugar yield due to lower cane yield, while late fertilizer application resulted in lower sugar yields due to lower juice quality rather than any loss in growth. Nitrogen fertilizer application to sugarcane on clay soils in subtropical South Texas is not required on plant cane crops, and should be at least at or above the level of 224 kg ha^{-1} used in this study in ratoon crops. Timing of a single application should be in March or April, or split into 2-3 applications on clay soils.

INTRODUCTION

Considerable research has been conducted on sugarcane responses to N fertilization worldwide. Sugarcane is grown under a wide variety of conditions, and recommendations have evolved in each region based on local climate and soils. Only South Africa uses a system of soil and plant sample analyses on which to base fertilizer recommendations (Meyer et al., 1989), and these are for soils with a pH range of 5.1 to 6.7. The organic soils of south Florida require no N fertilization at all to grow cane (Anderson, 1990). In Australia a recommendation of between 160 and 200 kg N ha^{-1} on ratoon crops is considered as a reasonable compromise between the need not to unduly raise input costs or lose yield potential (Keating et al., 1993). Cuban fertilizer recommendations follow closely those developed for south Texas consisting of none or very small amounts of N on plant cane, moderate amounts on the first ratoon and increasing to its highest level in the second and following ratoons (Alomá, 1974; Thomas et al., 1985).

Researchers have only a limited understanding of the impact of N supply on N uptake by the crop; the impact of N uptake on crop development, biomass production and sugar accumulation; and the "carry-over" effects of N nutrition on subsequent ratoons. Research on N can deliver benefits in the following areas: practices that result in reduced fertilization costs, better nutrition resulting in higher yields, maintenance of long term soil fertility, and protection of the environment (Keating et al., 1993). Progress can be made in all of these areas by matching fertility rates to soil and environmental conditions.

Very little has been done on how fertilization practices should be adjusted depending on soil type. Overfertilization frequently reduces sucrose content (Thomas and Schmidt, 1981), and this effect of excess N was observed to be greater on clay soils (Alomá, 1974). Denitrification has been shown to be a significant loss of fertilizer N on heavy-textured soils (Keating et al., 1993). Recommendations for N application on clay soils in Texas include higher rates and split applications due to shallow rooting (Rozeff, 1990). Fertilizer N is vulnerable to loss by denitrification and leaching of NO_3^--N which suggests the need for split fertilizer application. However, split applications of N has rarely been found to provide any significant benefit (Bieske, 1972; Keating et al., 1993).

The objective of this study was to determine the effect of rate and timing of N fertilizer application on sugarcane growth, and to determine optimum fertilization practices for sugarcane yield in a subtropical climate on calcareous clay soils.

MATERIALS AND METHODS

A field study was conducted in the Lower Rio Grande Valley of Texas, northwest of the town of Mercedes on the Texas A&M University Agricultural Research & Extension Center Annex (97º 56" 12' W latitude, 26º 9" 42' N longitude), on a Harlingen clay soil (very-fine, montmorillonitic, hypertheremic Entic Chromustert) (Jacobs, 1981).

Following a 6-month fallow period, the field was planted in sugarcane in the fall of 1988. The cultivar NCo310 and was planted in rows spaced 1.5 m apart by placing overlaping seed pieces from heat treated seed cane in the furrow and covering with about 15 cm of soil. Treatments consisted of different rates and timings of N fertilizer application. Fertilizer rates were 0, 56, 112, 168 and 224 kg N ha^{-1}; and application timings were all in February, April, or June; or split equally on all three application dates using only the 112, 168 and 224 kg N ha^{-1} rates. This gave a total of 16 treatments which were replicated 4 times in a ramdomized block design. The fertilizer treatments were applied by banding in the shoulder of the bed in plots six rows wide by 15.3 m in length. Fertilizer treatments were applied annually on the same plots for the full duration of the study. Standard cultural practices for the area were used to grow the crops including flood irrigation, weed control and pesticide application (Staff, 1975).

Plant growth and soil chemical property measurements were taken three or four times each season in each plot. Stalk population was determined in each by counting all stalks in a 3.1 m section of row. Two stalks were randomly selected from each plot, leaves were stripped, stalk length was measured to the growing point, and leaf area was determined on all leaves using a LiCor 3100 Area Meter. Soil samples were taken by compositing three cores taken from random locations within each plot to a depth of 25 cm. Soil were analyzed for NO_3^--N by KCl extraction (Keeny and Nelson, 1982) using a Wescan Ammonia Analyzer, reducing NO_3^- to NH_4^+.

Sugarcane yields and quality were determined each year by first taking 15-stalk subsamples from each plot. Stalks were crushed using a Squier Top Hydraulic Roller Mill at 1.7 x 10^7 Pa (2,500 psi) and the juice was analyzed for total dissolved solids (Brix) using an ABBE refractometer, sucrose concentration (Pol) using a saccharimeter, and electrical conductivity.

Juice purity was calculated as: Brix/Pol, and cane sucrose content was determined by the Winter-Carp formula (Chen, 1985). Cane yields were determined by harvesting and weighing all cane from a 46.5 m area from the middle two rows of each plot. Sugar yield was calculated by multiplying the cane yield by the percent cane sugar concentration.

At the conclusion of the study, soils were sampled from each plot and were analyzed by the Texas Agricultural Extension Soil Testing Laboratory. All data were analyzed statistically using the GLM procedure of the SAS software system (SAS Institute, Inc., 1988).

RESULTS AND DISCUSSION

Seasonal Plant Growth and Soil Nutrient Status

Sugarcane stalk population was very high early during the plant cane crop then declined over time during the first growing season (Fig. 1a). In subsequent crops, stalk population varied between sampling dates but showed no consistent pattern over time. Increasing N application rate had no effect on stalk population in the plant cane crop but increased stalk population in the first, second and third ratoon crops (Fig. 1b). Timing of N application had no effect on sugarcane stalk population.

Sugarcane stalk height was affected by rate of N application as well as by timing of application in the three ratoon crops. While increasing N rate generally resulted in greater stalk height on all sampling dates in the first through third ratoons (Fig. 2), increased growth rates with increasing N applied was most evident in the second ratoon crop (Fig. 2b). Early fertilizer applications in February or April, or split applications, resulted in greater stalk heights when measurements were made early in the season compared to the June application date (Table 1). At the early seasonal samplings, stalk length for the June application timing averaged 60 to 76% of the average of the other three fertilizer application timings depending on year. Stalk height recovered later in the season from the lost growth caused by the delayed fertilizer application, but by the fall samplings stalk length for the June fertilizer application timing still ranged from 93 to 96% of the other three fertilizer application timings. In the second ratoon crop, stalk length measured in September for the February fertilizer application timing was significantly less than for the April and split application timings (Table 1), indicating that the earliest fertilizer application timing treatment may have run out of N before maximum growth was achieved. Stalk heights for the split fertilizer application timing were always the highest or not significantly different for the treatment having the highest mean.

Sugarcane leaf area increased over time in each crop, but varied considerably between crops, due to variations in growing conditions. Increasing N application did not have a significant effect on leaf area index in the first ratoon crop, but caused a linear increase leaf area in the second and third ratoon crops (Fig. 3).

Average soil NO_3^--N levels were high initially in the plant cane crop and declined steadily during the first season (Fig. 4a), and were low all season long in the ratoon crops. Most of the time, soil NO_3^--N levels showed no response to N fertilizer application rates. Of the 13 samplings done in the four crops at different times during the growing season, soil NO_3^--N showed a statistically significant response to N application only three times (Fig. 4b). Soil NO_3^--N also showed a response to timing of N application in only three samplings. These consisted of significantly higher NO_3^--N levels for the timing treatment that had received fertilizer most recently before the sampling (Table 2).

Sugarcane Yield and Quality

Sugarcane cane yields showed no response to rate or timing of N fertilizer application in the plant cane crop. In the first through third ratoon crops cane yields increased linearly with increasing N application rate (Fig. 5a). Cane yield increased 0.190 Mg of cane per kg of N applied in the first ratoon, and 0.266 Mg of cane per kg of N applied in the second ratoon crop indicating a greater response to N in the second ratoon than in the first. Fertilizer timing affected cane yield only in the second ratoon crop where yields were lower for the February application timing than for the April, June or split timings (Table 3).

Cane sucrose concentration was not affected by N application in the plant cane crop. Cane sucrose concentration showed significant quadratic responses to N application in the first through third ratoons, increasing with N applied at low rates, but then declining at higher application rates (Fig. 5b). The June application timing reduced sucrose concentration compared to the other application timings in the second ratoon crop, but application timing had no effect on sucrose concentration in any other crop year.

While N application did affect cane sucrose concentration; the relative effects, though significant, were slight compared to the effects on cane yield. Therefore sugar yield responses to N application were very similar to cane yield responses to N rate and timing. Sugar yield increases due to rate of N application were not significant in the plant cane crop, were quadratic in the first and second ratoons, and were linear in the third ratoon (Fig. 5c). Fertilizer timing affected sugar yields in one crop. In the second ratoon a significant reduction in cane yield for the February application timing, and a significant reduction in cane sucrose content for the June application timing resulted in significantly lower sugar yields for both of these timings compared to the April or split application timings (Table 3).

Juice quality parameters were affected by N application in all crops except the plant cane crop. Brix and Pol showed significant quadratic responses to N application rate in the first through third ratoons, and purity and electrical conductivity also showed significant quadratic responses to N rate in the first and second ratoons (Fig. 6). Brix, Pol and purity increased with increasing N at lower N application rated but then decline as N increased at higher N application rates. Electrical conductivity, in contrast, declined with increasing N application at low N application rates but then increased with increasing N at high N application rates. Potassium is the main component of the ash content of the juice, which is essentially what is being measured by the electrical conductivity measurement. The June application timing caused significantly lower Brix, Pol and purity in the second ratoon crop, and significantly lower Brix in the third ratoon crop compared to the other application timings (Table 4).

Final Soil Nutrient Status

Soil samples taken after the last harvest showed no differences in any of the fertility parameters measured due to the N application treatments applied for the previous four years (Table 5). Average organic matter levels were somewhat higher than normal for soils in the Rio Grande Valley which may have been a function of the heavier texture of this soil. Salinity levels also were moderate, which is higher than what is normally found and again may have been due to the high clay content of this soil.

CONCLUSIONS

Sugarcane stalk population started out high following planting then declined during the first crop, but was relatively stable during each season and from year to year thereafter. Increasing N application consistently increased stalk population, so a good fertilizer program is important to maintain a good stand of sugarcane. Both leaf area and stalk height were increased by N application, but the effect was much greater on stalk height than on leaf area. Delayed fertilizer application resulted in lost early growth which was mostly but not always fully made up by the end of the growing season. Soil NO_3^--N levels started out high following planting, a result of mineralization stimulated by tillage and soil preparation. Soil NO_3^--N levels rarely increased due to N application and that was usually in samples taken soon after application, further confirming that this is a poor indicator of N availability to the crop.

Yield responses to N application were generally similar to those observed in previous studies. Cane growth did not respond to N application in the plant cane crop, then responses to N increased in the first and second ratoons. Cane yield responses to increasing N application have typically been found to be quadratic on lighter textured soils in the Rio Grande Valley peaking at 150 to 180 kg N ha^{-1}, but were linear in this study, indicating a greater need for N on clay soils. While N application had generally detrimental effects on juice quality, the magnitude of these effects were small compared to cane growth responses and therefore had only minor effects on sugar yield. Increased sugar yield due to increased cane yield may not, however, be a gain. More cane must be harvested, hauled and processed resulting in increased costs. The effect of application timing described earlier on stalk growth was also evident in sugar yield although the causes were not always the same. Early fertilizer application resulted in lower sugar yield due to lower cane yield. The same effect was found in stalk growth measurements. Late fertilizer application resulted in lower sugar yields due to lower juice quality rather than any loss in growth.

Fertilizer recommendations for sugarcane based on the results of this study should call for somewhat higher rates of N application on clay soil than for the same cultivars on lighter textured soils; and also split applications to more closely match N availability with crop need, a practice which has not shown to be of any benefit on sandier soils.

ACKNOWLEDGMENT

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Table 1. Sugarcane stalk heights for different N fertilizer application timings averaged across fertilizer rate on different sampling dates in each of three crop years.

	First ratoon			Second ratoon			Third ratoon		
Sampling date -	19 Jun	6 Aug	19 Sep	4 Jun	5 Aug	19 Sep	27 Jul	31 Aug	20 Oct
fertilizer timing	cm								
Feb	75 a[1]	133 a	194 a	50 a	122 ab	169 b	74 a	102 bc	153 ab
Apr	75 a	146 a	200 a	42 b	126 ab	199 a	71 a	107 ab	155 ab
June	44 b	113 b	187 a	34 c	116 b	176 b	52 b	95 c	145 b
split	73 a	136 a	189 a	44 ab	133 a	198 a	78 a	114 a	162 a

[1] Means in each column followed by the same letter are not significantly different.

Table 2. Soil NO_3^--N levels for different fertilizer application timings on different sampling dates in the plant cane and second ratoon sugarcane crops.

Fertilizer application timing	Plant cane		Second ratoon
	23 May	27 Jun	4 Jun
	ppm		
Feb	5.11 a[1]	2.84 b	0.51 b
Apr	5.67 a	5.61 a	0.55 b
June	1.28 b	1.89 b	1.21 a
split	3.98 a	3.31 b	0.77 b

[1]Means in each column for each site followed by the same letter are not significantly different

Table 3. Cane yield, sucrose content, and sugar yield for different N fertilizer application timings on sugarcane in the second ratoon crop.

Fertilizer application timing	Cane yield	Sucrose content	Sugar yield
	Mg ha^{-1}	kg Mg^{-1}	Mg ha^{-1}
Feb	86.9 b[1]	132.3 a	11.5 b
Apr	103.0 a	129.8 a	13.3 a
June	96.8 a	124.7 b	12.0 b
split	100.4 a	129.9 a	13.0 a

[1]Means in each column followed by the same letter are not significantly different.

Table 4. Selected sugarcane juice quality parameters for different fertilizer application timings in the second and third ratoon crops.

Fertilizer application timing	Second ratoon			Third ratoon
	Brix	Pol	Purity	Brix
	%			
Feb	19.7 a[1]	17.7 a	89.9 a	19.3 a
Apr	19.5 a	17.4 a	89.4 a	19.1 a
June	19.1 b	16.8 b	88.3 b	18.3 b
split	19.5 a	17.4 a	89.6 a	19.1 a

[1] Means in each column followed by the same letter are not significantly different.

Table 5. Soil chemical properties and their relative rating according to the Extension Soil Testing Laboratory averaged for all treatments on 26 Jan 1993 after the third ratoon crop.

NO_3^--N	P	K	Ca	Mg	S	Na	salinity	pH	organic matter
ppm									%
1.0	145	585	20513	1362	214	501	1214	8.2	2.0
very low	very high	very high	very high	high	high	moderate	moderate	moderately alkaline	

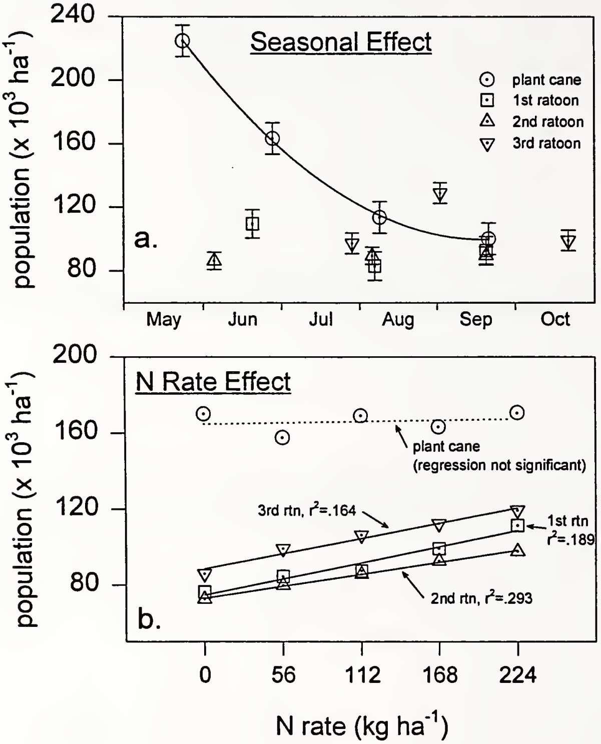

Figure 1. Sugarcane stalk population over time and at different N application rates for the plant-cane through the third-ratoon crops. Error bars represent LSD for the mean. Significant regressions were linear.

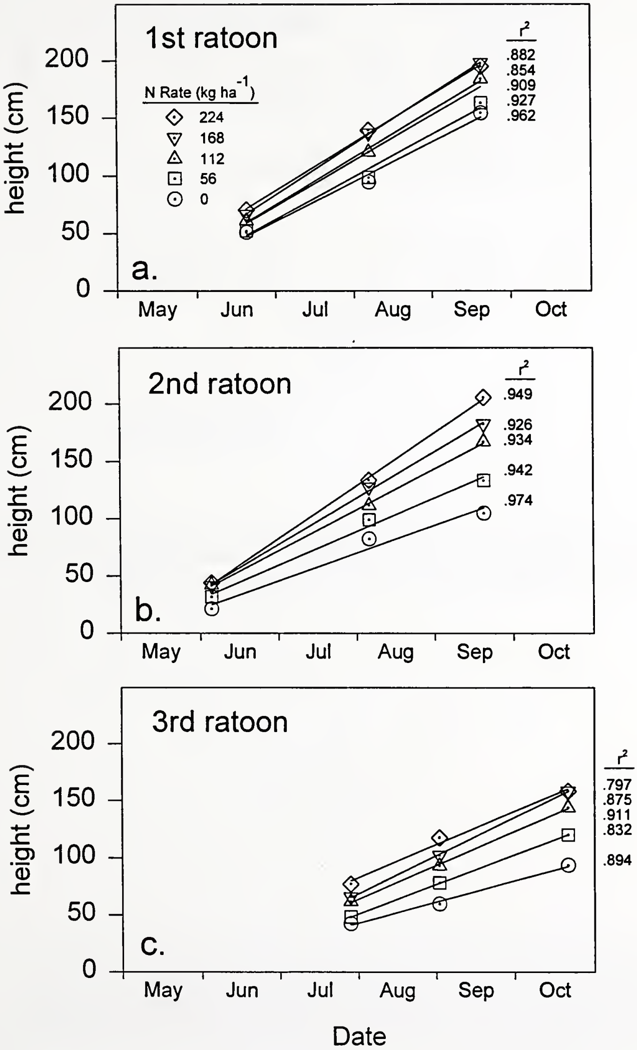

Figure 2. Sugarcane stalk heights over time for different N application levels for the first- through the third-ratoon crops. Significant regressions were linear.

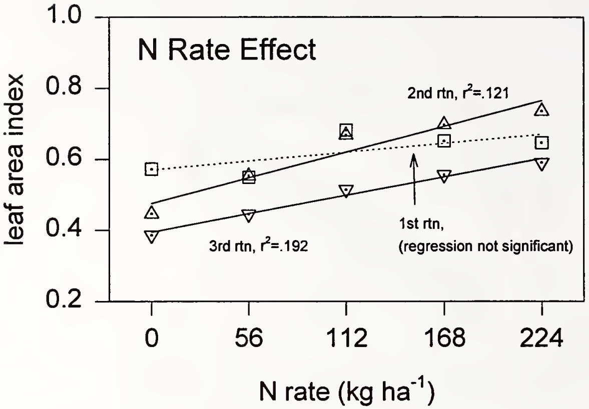

Figure 3. Sugarcane leaf area index over time for the plant-cane through the third-ratoon crops; and sugarcane leaf area index at different N application rates for the first- through the third-ratoon crops. Significant regressions were linear.

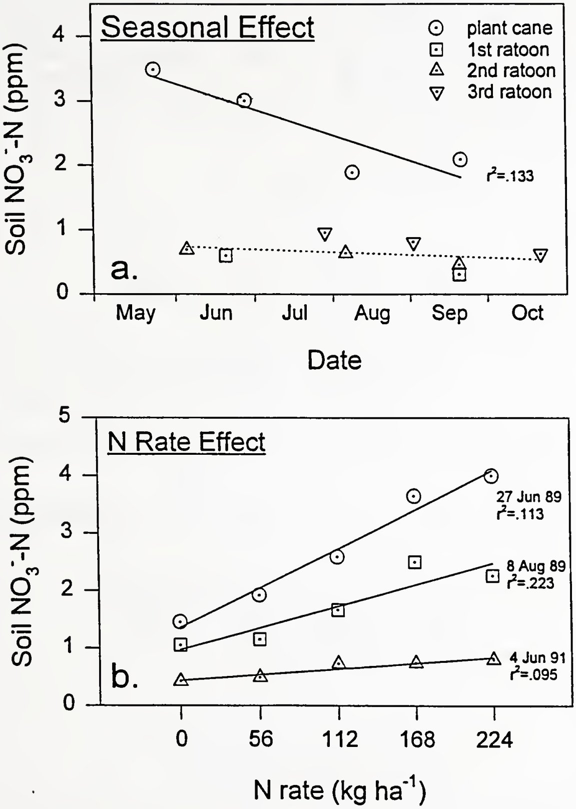

Figure 4. Soil NO_3^--N levels over time for the plant-cane through the third-ratoon crops; and soil NO_3^--N at different N application levels on selected sample dates. Where significant regressions were found, effects were linear. The regressions of soil NO_3^--N over time in the first through third ratoons were not statistically significant.

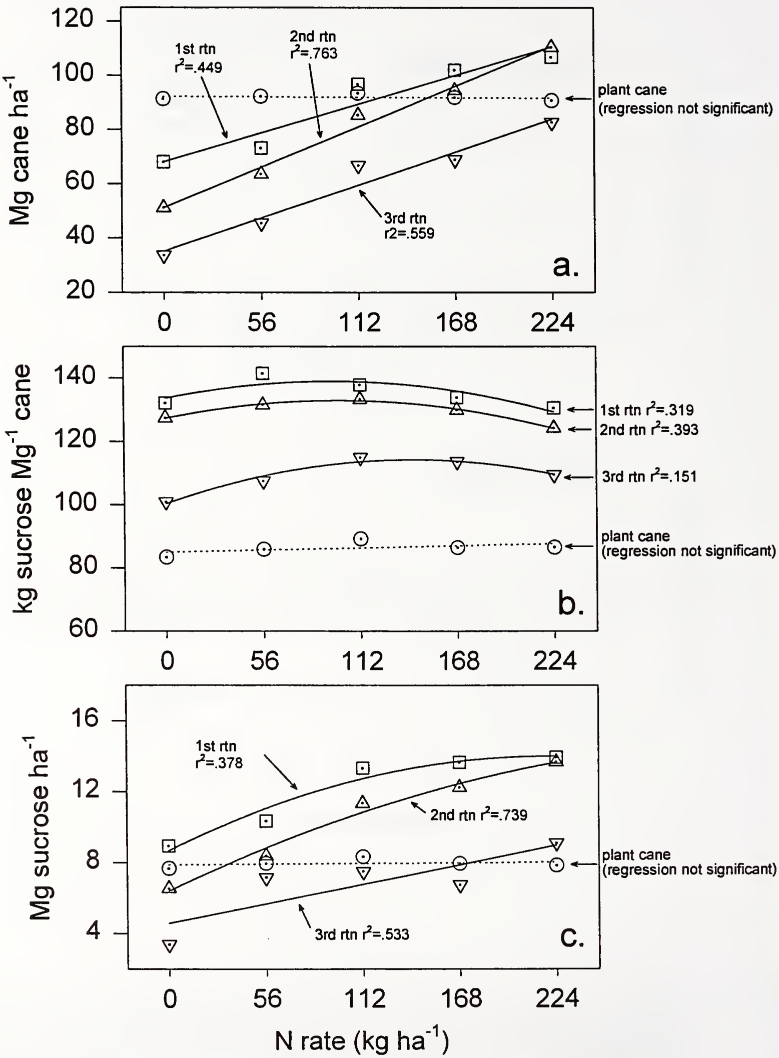

Figure 5. Cane yield, sucrose content, and sugar yield at different N application levels for plant-cane through third-ratoon sugarcane crops. Significant regressions were linear or quadratic, as indicated by the regression line drawn.

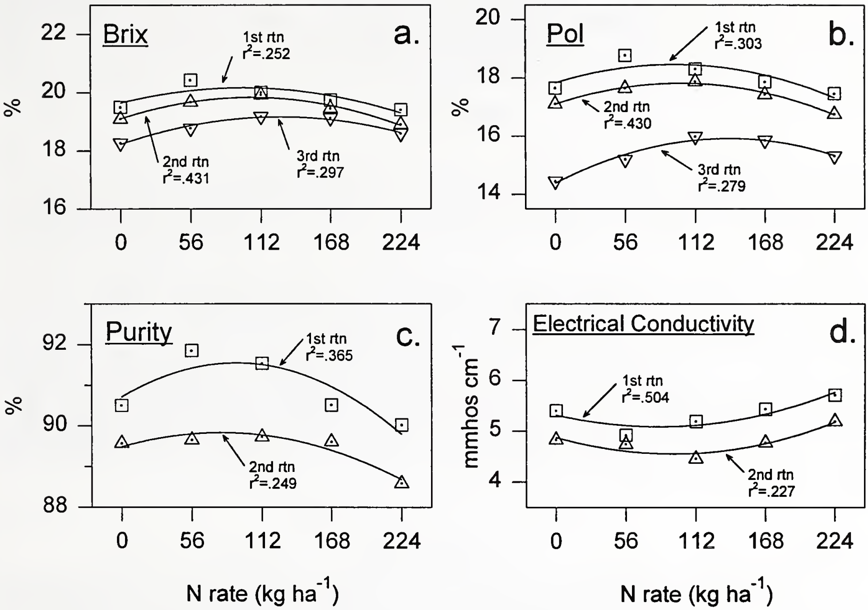

Figure 6. Sugarcane juice quality parameters for different N application levels in the first through third ratoon crops. Significant regressions were quadratic.

YIELD COMPONENTS OF SUGARCANE SUBJECTED TO FLOOD AT PLANTING

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ABSTRACT

In the Everglades of Florida, sugarcane (*Saccharum* spp.) fields occasionally are flooded by unseasonally heavy rains that may occur soon after planting. This can lead to extensive stand reduction and the need to replant, but is dependent on cultivar and the timing of the flood relative to planting. The purpose of this experiment was to evaluate flood tolerance and changes in yield components of major Florida sugarcane cultivars when subjected to flooding soon after planting. The experiment was run for two crop years, with four cultivars planted at three dates 18 d apart in a field bisected by a levee. Three days after the last planting, one half of the field was flooded for 10 d. At harvest, millable stalk populations were reduced 6 to 26% in plant cane and 10 to 21% in the ratoon crop. Cane and sugar yields were reduced by flooding in all cultivars for both the plant-cane and ratoon crops. Flooding 18 d after planting was the most injurious to the germinating cane, but the slower germinating cultivar, CP 72-1210, suffered less loss than other clones. It appeared dormant cane could tolerate flooding much better than cane in active stages of germination and emergence. Sucrose concentration and stalk weight were not reduced by flooding. Stand losses due to flood lasted through both crop years, indicating sugarcane has limited capacity to overcome losses incurred at planting.

INTRODUCTION

Some of the most productive agricultural land in the U.S. is found in the Everglades Agricultural Area (EAA), along the southern shore of Lake Okeechobee in Florida. In the EAA, sugarcane (*Saccharum* spp.) and winter vegetables are grown on Histosols (muck soil) which developed under flooded conditions. With the advent of agriculture in the 1920s and coincidental drainage, the soil has subsided, partly through shrinkage and compaction, but mostly due to microbial oxidation (Stephens and Stewart, 1976). Lands that had soil depths of 3 m above bedrock in 1928 now have only 0.6 to 1.0 m.

With a greatly reduced soil profile, water management becomes more difficult. Fields are sub-soil irrigated by raising water levels in the ditches and canals, allowing water to run laterally over the nearly impervious limestone bedrock and through the soil profile. Drainage is accomplished by pumping out the ditches and canals. When soil depths are a meter or less, there is little room for manipulating water table depth, which can prove disastrous when there are heavy rains.

The climate of the EAA is sub-tropical, with a unimodal rainy season from May until October. It is during the cool, dry season from November until April that vegetables are grown, and sugarcane is both planted and harvested (cane has a 1 yr growing period). The common crop cycle lasts 4 years: the plant-cane crop followed by three ratoon crops. During the dry season, occasional heavy rains may flood much of the area. Efforts are made to drain fields, since

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vegetables and newly-planted sugarcane are at risk.

Compared to most crops, sugarcane is very tolerant of high water tables and flooding (Deren et al., 1991a,b ; Deren et al., 1993; Carter, 1976; Deerr, 1925; Kang et al., 1986; Roach and Mullins, 1985; Sartoris and Belcher, 1949; Srinivasan and Batcha, 1962; Stevens, 1948). Well-established cane can survive months of continuous flood. However, recently planted cane appears to be much more vulnerable to damage from flooding. Fields where cane is germinating or just emerging will often suffer substantial stand loss and require replanting. Path coefficient analysis has shown that sugar yield is determined largely by stalk population (Kang et al., 1983; Kang et al., 1989).

The decision whether to replant or not is not taken lightly; cane planting is costly. Land must be prepared and seed cane cut. Because sugarcane is vegetatively propagated, 1 ha of cane is needed to plant 10 ha. This seed cane must be taken from what was to be harvested for milling, thereby reducing income.

Several factors may influence the stand establishment in a cane field flooded soon after planting. From our observations in commercial fields, the duration of flood and its timing relative to planting appear to be major factors. In addition, cultivars vary for how rapidly they germinate and emerge (Glaz and Ulloa, 1992). There has been considerable research done on flood tolerance of mature cane, but there is very little information on the effect of flooding on newly-planted cane, even though these effects may last for several crop years. The purpose of this experiment was to evaluate the timing of flooding on stand establishment and yield components of major sugarcane cultivars grown in Florida.

MATERIALS AND METHODS

The test was planted on a Pahokee muck (Euic, hyperthermic, Lithic, Medisaprist) at the University of Florida's Everglades Research and Education Center. Four extensively-grown Florida sugarcane cultivars were chosen for evaluation (Glaz, 1994): 'CP 72-1210', 'CP 80-1827', 'CP 72-2086', and 'CL 73-239'. The CP clones were developed by the public breeding program at Canal Point, FL (Miller et al., 1981; Miller et al., 1984; Glaz et al., 1990) and the CL clone was developed by US Sugar Corporation, a private company. The test site, a 2.3 ha field of uniform soil type and depth that was previously cropped to sugarcane, was divided in half to create two separate field environments: flooded and a non-flooded control. A soil dike, 1 m high and 3 m wide, was constructed to separate the environments and to facilitate short-term flooding of the one environment. This arrangement was necessary due to the extreme difficulty of randomizing flood treatments in these soils and follows a well-established precedent (Deren et al., 1991a,b; Deren et al., 1993).

Test cultivars were planted on three different planting dates in randomized complete blocks with six replications in each environment. Experimental units were arranged in a split-plot design within the two environments, with planting date as the main plots and cultivars as sub-plots. Cultivars were planted in three-row plots, 10 m long with 1.5 m between rows. Fertilizer was applied (765 kg/ha 0-14-37 NPK) according to soil test recommendations as an in-furrow band at time of planting. Planting dates were separated by 18d: 22 January, 10 February, and 28 February, 1992. Three days after the last planting, water was pumped onto the flooded environment. Within 24 hr a 10 cm deep flood covered the soil surface and was maintained for 10 d. The control environment was maintained in a normal, drained condition and was protected from seepage from the flooded environment by a drainage ditch as well as the soil levee. After the 10 d flood, water was drained off the flooded environment through the ditches. Subsequent to the flooding, both environments were treated identically.

The test was sampled 4 February 1993 and 10 February 1994. Yield data of mature cane were determined from stalk populations and mill samples. Stalk populations were determined by counting the number of harvestable-size stalks in each plot. A 10-stalk sample was harvested from the center row of each plot to determine stalk weight. These samples were then milled to determine sucrose concentration as percent by weight and sugar yield (Mg ha^{-1}) (Arceneaux, 1935).

Response variables were stalk weight (kg^{-1}), stalk number per plot, sucrose concentration (%), sugar per ton cane (kg Mg^{-1}), cane yield (Mg ha^{-1}), and sugar yield (Mg ha^{-1}). Data were analyzed as in previous flooding studies, where environments (flood and control) were treated like separate locations in the analysis of variance (Deren et al., 1991a; 1993). For a simple comparison of the effects of flooding on stalk number, a percent reduction was calculated. This was the difference between the two environments expressed as a percent of the control.

RESULTS AND DISCUSSION

Because so many factors must be evaluated and considered simultaneously, we have chosen to discuss the results through the major sources of variation from the analysis of variance.

Flooding

Typically, soil within a field in the Everglades is quite homogeneous, and would be particularly so in a parcel as small as our test site. In addition, the site had been uniformly cropped for at least 10 yr prior to the experiment. Therefore, we maintain that most of the differences observed between the environments were due to flooding.

The primary value of a sugarcane crop is in how much sugar it produces per hectare. Flooding significantly reduced the two-year mean sugar yield, primarily by reducing stalk number, which in turn was responsible for decreased cane yield (Table 1). Mean stalk weight, the other yield component contributing to cane yield, was not affected by flood. The only yield component that increased with flooding was the sucrose concentration. This has been observed in other tests when mature sugarcane was flooded for prolonged periods, stressing plants (Deren et al., 1991a), but these plants were stressed very briefly, 11 mo before harvest.

Crop Years

In general, sugarcane crops decline in cane yield in later ratoon crops, eventually requiring replanting. This is essentially a feature of plant age and whatever stresses may be caused by parasites, pathogens, etc. on a perennial host. In this test, cane yield was actually greater in the ratoon crop than in the plant-cane crop (Table 1). Stalk weights were greater in plant cane, but the difference was not enough to compensate for the greater stalk numbers observed in the ratoon crop, which was responsible for the increased cane yield in the ratoon.

Although cane yield was greater in the ratoon crop, mean sugar yields were the same for both crop years (Table 1). The greater sucrose concentration in the plant-cane crop compensated for the lesser cane tonnage (Table 1). Sucrose concentration is a feature of a genotype, but is strongly affected year-to-year by environment.

Cane yield was less in the flooded crop than in the control over both crop years (Fig.

1). Reduced cane yield was due to the reduced stalk number in the flooded treatment (Table 1). This in turn was responsible for the reduced sugar yield in the flooded treatment.

Planting Date

Planting date had little effect on the two-year mean values for yield and yield components (Table 1). But within a given year and for individual clones, planting date clearly influenced subsequent yields. In plant cane, the second planting date (18 d before flooding) had the greatest stalk number reduction in all clones except CP 72-1210 (Fig. 2). The second planting date continued to have the greatest stalk number reduction in the ratoon crop and had a two-year mean stand loss of -22% (Table 2).

The stage of germination probably was responsible for the effect of planting date on stalk number reduction in the flood environment. Cane planted for 18 d generally will break bud and begin emerging. The tender shoots are very vulnerable to damage. The one exception was CP 72-1210, which was less affected in the second planting. CP 72-1210 is known as a slow-germinating cane, so it was still largely dormant, conferring protection when the flood was applied after 18 d. By contrast, cane planted at date 1 (36 d before flooding) was better established and able to withstand stress. Some shoots of the more rapid-germinating cultivars even were able to emerge above the surface of the flood water. Buds that have not begun germination are protected from environmental hazards and stress by the bud scales. The third planting date was flooded immediately after planting, so buds were still dormant and protected.

Cultivars

Mean values for all yield components varied among cultivars (Table 1), and all significant ($P \leq 0.01$) interactions had cultivars as a source of variance. Relative values for stalk weight and sucrose concentration would be expected to vary among cultivars, as they are determined mostly by genotype and are selected for in breeding programs.

There were no significant ($P \leq 0.01$) interactions affecting stalk weight, sucrose content, or sugar per ton cane. Stalk number, however, varied significantly in the interactions of environment x cultivar, year x cultivar, date x cultivar, environment x date x cultivar, and year x date x cultivar. These interactions reflect the influence of flooding on germination and stalk number, and how genotypes vary in their response to flood. Stalk numbers of all cultivars were reduced in the flooded environment, but cultivars were affected differently at different dates (Fig.2). The significant ($P \leq 0.01$) interactions involving date x cultivar likely were due to the variability among cultivars for the degree of germination at the time of flooding as discussed above. Cane and sugar yield also had significant ($P \leq 0.01$) interactions for environment x cultivar, year x cultivar, and date x cultivar, which is an expression of the influence of stalk number on yield. Mean percent reduction in stalk number ranged from 6 to 26% in plant cane and 10 to 21% in ratoon (Table 2). CP 80-1827 was the most affected by flood, with losses >20% each year. CP 72-1210 and CL 73-239 were more flood tolerant.

CONCLUSIONS

Sugarcane genotypes vary for their tolerance to being flooded soon after planting, but all these major Florida cultivars were affected by flooding to some degree. Stand population appears to be determined in part by the degree of germination/emergence of a clone at the time of flooding. Growers need to consider the germination characteristics of a cultivar when deciding whether to replant after a flood. It is important to note that stalk number reductions originating in the very earliest stages of the crop cycle persist not only through that crop year, but also into the ratoon crop. Sugarcane is a bunch grass, where stools arise from primary shoots, and are filled out with subsequently developed tillers. Tillering can compensate for some gaps in a stand, but these varieties could not overcome the initial losses due to flooding, even two years after the flooding occurred.

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Table 1. Two year mean yield and yield components of four sugarcane cultivars exposed to flood after planting

	Stalk Weight	Stalk Number	Sucrose Conc.	ST‡	Cane Yield	Sugar Yield
	kg	per plot	%	kg Mg^{-1}	- Mg ha^{-1} -	
Environment						
Control	2.86	363**	8.86	133.9	94.3**	12.6**
Flood	2.84	310	8.99**	135.9	80.1	10.9
Year						
1	2.97**	302	9.31**	142.3**	81.6	11.7
2	2.74	370**	8.55	127.3	92.8**	11.8
Planting Date						
1	2.97	322	8.90	134.4	86.6	11.7
2	2.80	347	8.95	135.7	88.1	11.9
3	2.78	341	8.93	134.3	86.8	11.6
P	0.001	0.15	F<1	F<1	F<1	F<1
LSD (0.01)	0.14					
Cultivar						
CP 72-1210	2.62	347	8.96	134.6	83.5	11.2
CP 80-1827	3.44	311	8.73	130.3	98.8	12.8
CL 72-239	2.36	385	9.29	142.5	83.3	11.9
CP 72-2086	2.99	303	8.73	131.8	83.3	11.0
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD (0.01)	0.41	14.6	0.11	3.69	5.65	0.84

** Means which are significantly greater at $P < 0.01$

‡ ST = Sugar per ton cane

Table 2. Mean percent reduction in sugarcane stalk populations of four cultivars due to flooding.

	Plant cane	First-ratoon	2-year mean
	------------------------ % Reduction[†]------------------------		
CP 72-1210	6	16	11.2
CP 80-1827	26	21	22.9
CL 73-239	10	10	10.0
CP 72-2086	16	14	15.0
Planting Date 1[‡]	11	12	11.5
Planting Date 2	26	18	22.0
Planting Date 3	3	13	8.0

[†] Percent reduction is calculated as the difference between stalk counts in the flooded enviroment versus the control environment as a percent of the control.

[‡] Planting dates 1, 2, and 3 were 36,18, and 0 days before flooding respectively.

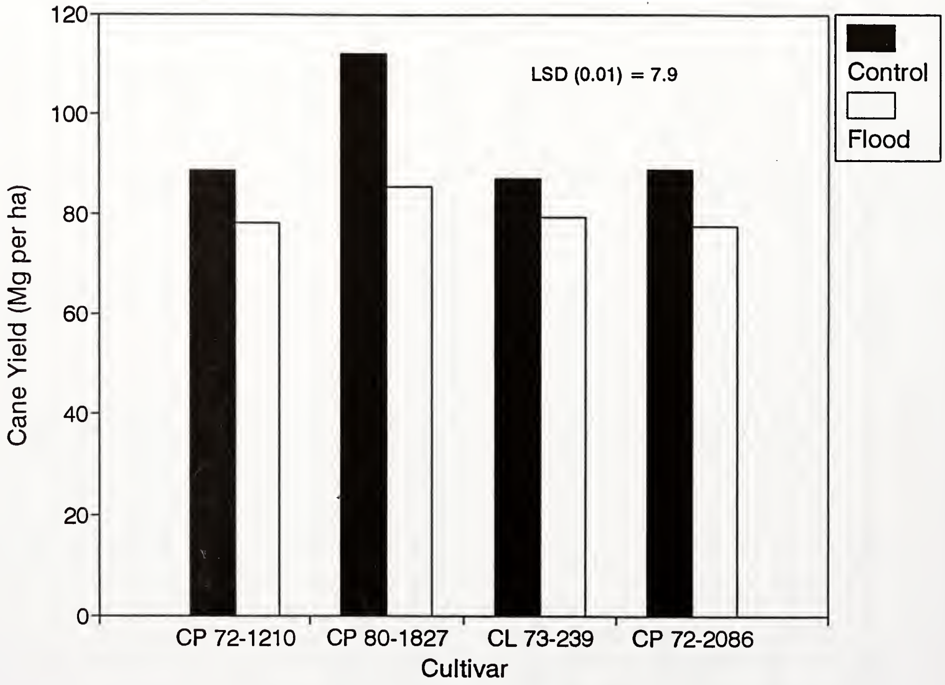

Figure 1. Two-year mean cane yield (Mg ha^{-1}) of four sugarcane cultivars grown in control and flooded environments.

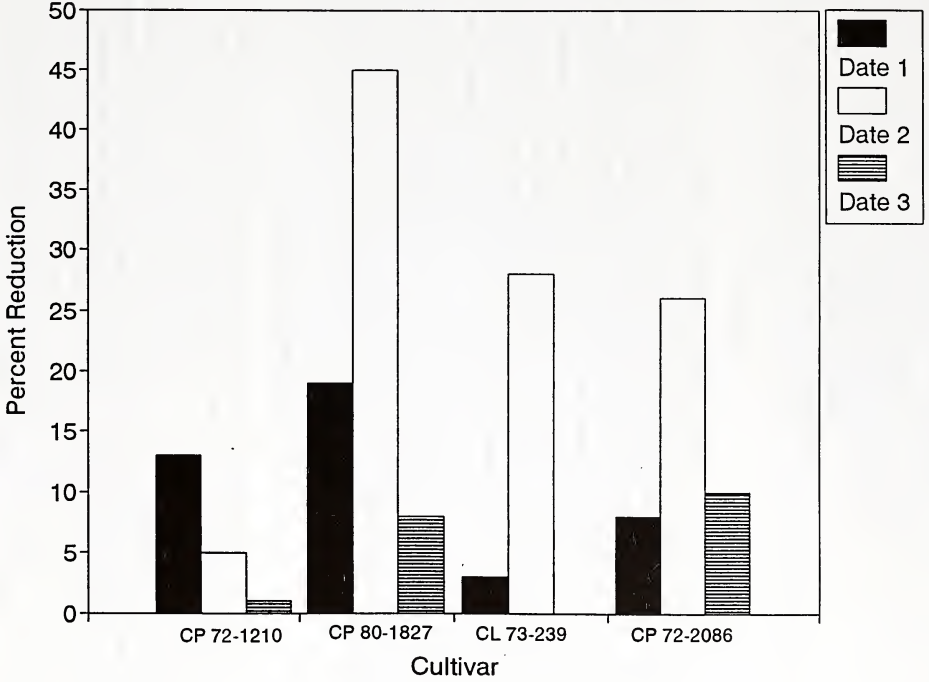

Figure 2. Percent reduction of stalk number due to flooding in the plant-cane crop of four sugarcane cultivars.

CHROMOSOME TRANSMISSION AND MEIOTIC BEHAVIOR IN VARIOUS SUGARCANE CROSSES

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ABSTRACT

Elite (commercial or near-commercial) sugarcane (*Saccharum*) is a tri-species hybrid derived from *S. officinarum* ($2n$=80), *S. robustum* ($2n$=60,80), and *S. spontaneum* ($2n$=40-128). Elite clones are crossed with these and other species for germplasm enhancement and cultivar development. Some cross combinations in *Saccharum* yield $2n+n$ progeny, but it has not been conclusively determined whether elite clones produce $2n$ gametes. Chromosome transmission was studied in 47 F_1, F_2, and BC_1 progeny derived in most cases from elite x exotic crosses. Hybrids of sugarcane x *Miscanthidium violaceum* or *Miscanthus sinensis* appeared to be from $n+2n$ chromosome transmission. Hybrids of sugarcane x *Miscanthus japonicus*, *S. robustum*, *S. spontaneum*, and F_2 and BC_1 progeny appeared derived from $n+n$ transmission. Hybrids from the exotic crosses *S. officinarum* x *S. robustum*, *S. officinarum* x *S. spontaneum*, *S. sinense* x *Erianthus elephantinus*, and *S. spontaneum* x *S. officinarum* appeared derived from $n+n$ transmission. Chromosome pairing was regular in progeny of Louisiana Purple (*S. officinarum*, $2n$ = 80) x Molokai 5829 (*S. robustum* $2n$ = 80), but all other clones had univalents, trivalents, or quadrivalents. About 26% of microsporocytes in a hybrid from NCo 310 x *Miscanthidium violaceum* were multiploid, but it is unclear whether these form functional diploid or polyploid microspores. Progeny analysis suggested that elite sugarcane clones produced only n megaspores.

INTRODUCTION

While sexual reproduction in most grasses occurs through the production and union of haploid gametes, studies of chromosome transmission in interspecific and intergeneric hybrids of sugarcane (*Saccharum* L.) have shown that exceptions to this rule are common. In the cross *S. officinarum* L. x *S. spontaneum* L., the sporophytic number of *S. officinarum* ($2n$ = 80) is transmitted to the progeny, a phenomenon observed first by Bremer (1923) and subsequently by others (Nair 1975; Price 1957). In these studies, chromosomes in microsporocytes of *S. officinarum* generally had bivalent metaphase I pairing and normal reduction and equational divisions while those in megasporocytes were unreduced. The F_1 x *S. spontaneum*, *S. officinarum* x F_1, and BC_2 clone POJ 2722 x F_1 (H 581 x *S. spontaneum*) also yielded $2n+n$ progeny (Bremer 1961a), as did *S. officinarum* x *S. sinense* Roxb. (Price 1957). Harlan and deWet (1975) stated that $2n+n$ reproduction is the most common and widespread form of spontaneous polyploidy.

Crosses of *S. officinarum* x *S. robustum* Brandes and Jesw. *ex* Grassl, *S. robustum* x *S. spontaneum*, and *S. sinense* x *S. spontaneum* yielded $n+n$ progeny (Price 1957). The mode of chromosome transmission has also been reported for other interspecific and intergeneric crosses (Price 1957): *S. sinense* x *S. officinarum* ($n+n$, $n+2n$), *S. sinense* x *S. spontaneum* ($n+n$), and *S. officinarum* x *Erianthus arundinaceus* (Retz.) Jesw. ($n+n$).

Elite (commercial or near-commercial) sugarcane is a tri-species hybrid derived from the exotic species *S. officinarum*, *S. robustum*, and *S. spontaneum*. Elite sugarcane clones are crossed with these and other exotic species for germplasm enhancement and cultivar development but the mode of chromosome transmission has not been thoroughly studied. Price (1957) stated that "complex" *Saccharum*, presumably hybrid derivatives in the BC_2 generation or higher, produced *n*+*n*, 2*n*+*n*, and *n*+2*n* progeny. A sugarcane cultivar crossed with *Sorghum bicolor* (L.) Moench yielded *n*+*n* hybrids (Subramonian 1991). Burner and Legendre (1993) showed that F_1 and backcrossed progeny from elite clones x *S. spontaneum* were *n*+*n*.

The first objective was to study chromosome transmission in various F_1, F_2, and BC_1 progeny to verify hybrids and production of 2*n*+*n* progeny. The second objective was to determine chromosome pairing in the plants.

MATERIALS AND METHODS

The study was conducted on inflorescence specimens from 41 clones, and root tip specimens from six clones. Some plants were thought to be 2*n*+*n* based on stalk diameter. Inflorescences were collected from 1990 through 1995 from plants grown under artificial photoperiod treatment at Houma, Louisiana, or from free-flowering plants at Oahu, Hawaii or Canal Point, Florida. Inflorescences were fixed and stained using standard procedures (Burner 1991). Tissue specimens of the 24 plants with prefixes 13, 65, 236, 347, GxI, PxM, and US 87 were from Florida (kindly provided by P.Y.P. Tai, USDA-ARS), and six with prefixes H 91 were from Hawaii (kindly provided by C. Nagai, Hawaiian Agricultural Research Center). Remaining specimens, including those for elite parental clones, were collected at Houma.

Four to 25 (mean = 12) microsporocytes of each clone were examined at metaphase I to determine chromosome number and chromosome pairing, and 25 cells were examined at telophase II for micronuclei frequency. Other meiotic stages were also studied as warranted. Chromosome number was estimated at mitotic metaphase (mean = 4 cells per plant) in root tips of the six plants (prefixes GxI and PxM) from Florida. Pollen stainability in 10 g L^{-1} I_2-KI was measured on samples collected at Houma. Data were arranged by cross (Table 1). Crosses 1 through 10 were elite x exotic crosses, crosses 11 through 15 were elite selfs, and crosses 16 through 19 were exotic x exotic crosses.

RESULTS

Univalents, multivalents, and micronuclei were observed in most parental clones (data not shown) and in most hybrids (Table 1), suggesting the production of aneuploid gametes. Only F_1 progeny of the H 91 series, *S. officinarum* x *S. robustum*, were meiotically stable. Nevertheless, meiotic pairing was generally normal as $\geq$90% of chromosomes paired as bivalents.

NCo 310 (elite) x US 56-42-3 (*Miscanthidium violaceum* Stapf) (Cross 1)

The parents were $2n = 112$ (Burner and Legendre 1994) and $2n = 28$ (Price 1968a), respectively. The F_1 parent (US 87-1022) of the F_2 plants was not sampled, but its full sib, US 87-1023, was $2n = 97$. Chromosome transmission to US 87-1023, and by inference the parental F_1 clone, was about *n*+2*n* except there were about 10 more chromosomes than expected. The F_2 progeny were $2n = 93$ to $2n = 96$ (*n*+*n*). The F_1 and F_2 clones had rather high frequencies of trivalents (0.79 to 1.98%), and some had quadrivalents. However, only moderate frequencies of telophase II micronuclei were observed. This suggested that most chromosomes were incorporated into the nucleus. About 26% of the microsporocytes of clone 13-6 were multiploid (two to seven nuclei per cell). Three F_2 clones (13-2, 13-10, and 13-13) had sessile spikelet pairs, atypical of the Saccharastrae subtribe, instead of one sessile and one pedicellate.

NCo 310 (elite) x IMP 3905 (*M. sinensis* Anderss.) (Cross 2)

The clone NCo 310 was $2n = 112$ (Burner and Legendre 1994). The *M. sinensis* parent IMP 3905 was not available for study, but the species typically is $2n = 38$ (Daniels and Roach, 1987). No F_1 clone was available for study. Three F_2 progeny of F_1 US 87-1018 were $2n = 87$ to 96, suggesting that F_1 clones were derived from $n+2n$ transmission and F_2 clones were from $n+n$ transmission.

NCo 310 (elite) x US 47-11 (*M. sinensis*) (Cross 3)

Parents were $2n = 112$ (Burner and Legendre 1994) and $2n = 38$ (Burner 1991), respectively. The F_1 clones, US 87-1020 and US 87-1021, were $2n = 94$. Thus, the cross produced $n+2n$ progeny like NCo 310 x IMP 3905. Clones US 87-1020 and US 87-1021 had rather high frequencies of univalents, trivalents, and telophase II micronuclei. The F_2 clone 236-21 also had univalents (11.19%) and telophase II micronuclei (4.44 per cell). Univalents and micronuclei indicate that gametes would be aneuploid. The F_2 progeny of US 87-1021, 236-14 and 236-21, were $2n = 108$ to 113, indicating an increase of about 14 chromosomes from F_1 to F_2 generations.

POJ 2725 x *M. japonicus* (Cross 4)

The F_1 clone PT 33-85 is an apparent $n+n$ progeny of POJ 2725 ($2n = 107$) x *M. japonicus* ($2n = 38$). Clone POJ 2725 is a BC_2 of *S. spontaneum* clone Glagah ($2n = 112$) (Li et al. 1948). Meiotic analysis indicated that PT 33-85 was $2n = 75$, similar to the chromosome count of $2n = 74$ by Li et al. (1948). Its chromosome pairing showed lower frequencies of univalents (5.47%), and higher frequencies of trivalents (7.60%) and quadrivalents (5.07%) than Li et al. (1948) reported: univalents (18.4%), trivalents (0.51%), and quadrivalents (0.68%). Pollen stainability was low (15%) probably due to meiotic irregularity.

CP 65-357 (elite) x IS 76-178 (*E. arundinaceus*) (Cross 5)

The chromosome number for CP 65-357 was $2n = 104$ to 115 (Burner and Legendre 1994). Clone IS 76-178 was not studied but was assumed to be $2n = 60$ based on chromosome counts of other *E. arundinaceus* clones from Sulawesi, Indonesia (Anonymous 1980). Two F_1 clones, US 87-1016 and US 87-1017, and four BC_1 clones (347-1, -2, -5, -6) were studied. The putative F_1 clones were $2n = 103$ to 100, respectively, with relatively few univalents and multivalents. Chromosome counts suggested that the progeny were selfs ($n+n$) of CP 65-357. However, further research is needed to determine their ancestry because it is possible that progeny were $n+2n$ with elimination of about 10 chromosomes.

The BC_1 clones were progeny of US 87-1017 x CP 82-1505 (cytology not studied), and were $2n = 100$ to 109 ($n+n$). The BC_1 clones 347-1 and 347-2 averaged 13.8 and 7.88 univalents per cell, respectively, but frequencies of telophase II micronuclei were nominal. Thus, the univalents may have arisen from premature disjunction. Multiploid microsporocytes were found in low frequency at pachytene in 347-2 (3%) and 327-6 (0.6%).

CP 65-357 (elite) x SES 273 (*E. elephantinus*) (Cross 6)

The chromosome count of CP 65-357 was made by Burner and Legendre (1994) and of SES 273 *E. elephantinus* Hook.f. by Burner (1991) and Mohan and Sreenivasan (1983). The F_1 hybrid was selected for relatively large diameter stalk, wide leaves, and erect leaf architecture. Chromosome counts indicated that US 82-44 ($2n$ = 101) was a self.

CP 79-348 (elite) x NG 77-199 (*S. robustum*) (Cross 7)

Clone CP 79-348 was $2n$ = 112 (Burner and Legendre 1994) and NG 77-199 was $2n$ = 166 (Burner 1991). Krishnamurthi and Koike (1982) described NG 77-199 as *S. officinarum*, although it appeared more like *S. robustum* in gross morphology and cytology. The F_1 hybrid US 94-97 was $2n$ = 114 to 137 (most counts were near $2n$ = 130) indicating that it was derived from $n+n$ transmission. The hybrid was meiotically irregular with almost 8% of chromosomes as univalents, and substantial numbers of trivalents and quadrivalents. Pollen stainability was 8% (male sterile).

Elite sugarcane x Open pollinated *S. spontaneum* (Crosses 8-10)

Three hybrids (US 94-82, US 94-83, and US 94-84) were derived from POJ 2222 ($2n$ = 107), one hybrid (US 94-87) was derived from CP 65-357 ($2n$ = 104 to 115), and one hybrid (US 94-93) was from HoCP 91-534 (2n = 100). Elite plants were open pollinated in a greenhouse with various clones of *S. spontaneum*. Progeny were $2n$ = 76 to 88, and had thin stalks and narrow leaf lamina typical of such F_1 hybrids. These chromosome counts are consistent with progeny of $n+n$ transmission (Burner and Legendre, 1993). Clones US 94-87 and US 94-93 were male sterile. Clone US 94-87 had abnormal meiosis in which cytokinesis failed at telophase I, meiosis II was absent, and pollen dyads (Bremer 1923) formed after telophase I. Meiosis of clone US 94-93 tended to stop at leptotene to pachytene followed by microsporocyte degeneration; it also had shriveled anthers with degenerated pollen.

Elite sugarcane x self (Crosses 11-15)

There were eight clones from this type of cross: US 94-51, US 94-71, US 94-72, US 94-74, US 94-75, US 94-76, US 94-77, and US 94-78. Chromosome counts for the elite, maternal parents (CP 79-332, LCP 85-384, HoCP 88-739, CP 57-614) were made for this study, and the count for CP 65-357 was made by Burner and Legendre (1994). Clone CP 88-772 was not analyzed. As expected all progeny were derived from $n+n$ transmission. Progeny tended to be rather meiotically stable; high univalent frequencies in US 94-74 appeared due to premature disjunction of bivalents.

Katha (*S. sinense*) x SES 372 (*E. elephantinus*) (Cross 16)

Price (1968b) determined that Katha was $2n$ = 91. Burner (1991) found that SES 372 was $2n$ = 20, although Mohan and Sreenivasan (1983) reported the clone was $2n$ = 40. Clone US 94-64 was $2n$ = 86 to 92, suggesting it was a self of Katha ($n+n$). It was conceivable, although unlikely, that the clone was from $n+4n$ transmission. While multiploid microsporocytes were observed in progeny of CP 65-357 x IS 76-178, none was observed in SES 372.

Louisiana Purple (*S. officinarum*) x Molokai 5829 (*S. robustum*) (Cross 17)

Louisiana Purple (= Black Cheribon) was $2n = 80$ (Brandes 1951). Meiotic analysis of Molokai 5829 ($2n = 80$) confirmed the count by Price (1965). Six F_1 hybrids were $2n = 80$ indicating exact $n+n$ transmission. Almost all chromosomes of the hybrids paired as bivalents, and telophase II micronuclei were rare. These were the most meiotically regular clones evaluated in the study.

Green German (*S. officinarum*) x IND 81-146 (*S. spontaneum*) (Cross 18)

Bremer (1923) determined that Green German New Guinea was $2n = 80$. In this study, however, its mitotic count was $2n = 102$ to 117. Thus, the Green German of this study was probably not the same clone studied by Bremer (1923), and may have been a hybrid of unknown ancestry. The clone IND 81-146 was about $2n = 56$, based on mitotic count, similar to the count of $2n = 54$ reported by Sreenivasan and Sreenivasan (1994). Three F_1 progeny were selected as putative $2n+n$ clones based on stalk diameter. Mitotic counts showed them to have $2n = 73$ to 85 chromosomes ($n+n$), consistent with crosses of elite x *S. spontaneum* (Burner and Legendre 1993) and not *S. officinarum* ($2n = 80$) x *S. spontaneum* (Bremer 1923; Nair 1975; Price 1957).

PIN 84-1 (*S. spontaneum*) x Muntok Java (*S. officinarum*) (Cross 19)

Parents had mitotic counts of $2n = 96$ and $2n = 138$ to 144, respectively. Muntok Java reportedly is $2n = 80$ (Rao and Vijayalakshmi 1962). Thus, the identity of the clone is suspect. Three F_1 progeny were selected as putative $2n+n$ clones based on stalk diameter. Mitotic analysis showed that F_1 hybrids were $2n = 99$ to 121 ($n+n$).

DISCUSSION

Elite varieties and cultivars are arguably among the most valuable germplasm available to sugarcane breeders due to their adaptability and productivity under cultivation. Yet few studies have been directed toward typifying their mode of chromosome transmission. Elite x exotic crosses with $2n+n$ transmission, in contrast to those with $n+n$ transmission, could have a significant positive impact on sugarcane improvement because of the rapid increase in chromosome number. Chromosome number seems to be positively associated with stalk diameter (Bremer 1929) up to some optimum point, perhaps $2n = 180$ to 220, beyond which plants have decreased stalk diameter and vigor (Bremer 1961b). Thus, the breeder could more rapidly transfer desired attributes from exotic clones into adapted, commercially useful clones with $2n+n$ as compared to $n+n$ transmission. This is particularly important in southern Louisiana where elite clones are more responsive to photoperiod induction than *S. officinarum* (Dunckelman 1977).

Elite clones are not known to produce $2n$ megaspores or $2n$ microspores. Multiploid microsporocytes (syncytes), reported in sugarcane as indirect evidence of $2n$ pollen (Price 1956), were found in progeny of the cross NCo 310 x US 56-42-3 (*Miscanthidium violaceum*). In addition to syncytes, desynapsis and first and second division restitution have been observed in elite sugarcane clones (Burner and Legendre 1993). These are alternative mechanisms for $2n$ microspore production. Production of $2n$ gametes in mega- and microsporogenesis may be governed by different genetic mechanisms (Bretagnolle and Thompson, 1995; Curtis and Doyle, 1992). Thus, production of $2n$ microspores does not imply production of $2n$ megaspores.

Chromosome transmission appeared to be *n*+2*n* for elite sugarcane x *Miscanthidium violaceum* (2*n* = 28) and *M. sinensis* (2*n* = 38). This type of transmission is opposite that desired. Additional cycles of recurrent breeding and selection are needed for desirable alleles to be recombined, or for elimination of whole chromosomes carrying agronomically undesirable traits from the exotic parent. Chromosome elimination may have occurred in CP 65-357 x IS 76-178 (*E. arundinaceus*) and has been reported in similar crosses (D'Hont et al. 1995). Conversely, chromosome increase occurred in NCo 310 x US 47-11 (*M. sinensis*). Relatively high chromosome counts (2n = 140 to 196) also were reported by Price (1965) for natural hybrids of *Saccharum* x *Miscanthus* Anderss.

Chromosome pairing was most regular in progeny of *S. officinarum* x *S. robustum* (99.18 to 100% bivalent pairing and no aneuploidy). All other clones had univalents (1.67 to 13.80% of chromosomes), and most had trivalents (0 to 7.60%) or quadrivalents (0 to 5.07%). Meiosis was irregular in elite sugarcane x open pollinated *S. spontaneum* to the extent that many of these clones were male sterile.

Chromosome pairing was consistent with reports for elite and hybrid clones. Price (1963) reported meiotic counts of 2*n* = 102 to 116 for four Hawaiian cultivars, with 95 to 100% of chromosomes paired as bivalents, and 0 to 5% as unpaired univalents. Singh et al. (1991) showed that 15 of 16 elite clones had significant numbers of cells with univalents (1.9 to 35% of cells), heteromorphic bivalents, lagging chromosomes at anaphase I, or unequal division. Burner and Legendre (1994) reported that univalents and multivalents were found at low levels in all of 21 elite clones, 10 of which were chromosomal mosaics.

Nair (1975) studied chromosome number (2n=86 to 143) and pairing in F_1 hybrids of *S. officinarum* x *S. spontaneum*, and found that 88 to 99% of chromosomes paired as bivalents and 1 to 12% were unpaired univalents. Roach (1969) stated that meiosis may be more irregular in progeny of *S. officinarum* x *S. spontaneum* from *n*+*n* transmission, because of partial or attempted allosyndesis, than from those from 2*n*+*n* transmission. Perhaps this explains why meiosis is reportedly so irregular in elite clones.

This study suggested that elite sugarcane clones produce only *n* megaspores based on progeny evaluation. However, studies of chromosome transmission in sugarcane are tedious, and only few populations or few progeny within a population can be surveyed in detail. Counts can also be unreliable in the presence of aneuploidy, chromosome mosaicism, and chromosome elimination. Thus, classical cytology may not be the most efficient means of searching for 2*n*+*n* progeny in sugarcane. Phenotypic selection of putative 2*n*+*n* progeny also is unreliable because of the potential for selfing and quantitative variation of most traits.

The application of molecular strategies, such as DNA amplification using male-specific primers coupled with flow cytometry, should facilitate large-scale cytological study of progeny populations and improve the likelihood of identifying 2*n*+*n* progeny. In the first step, putative hybrids are selected for the presence of male- or species-specific markers using polymerase chain reaction (PCR) methodologies (D'Hont et al., 1995; McIntyre and Jackson, 1996), or genomic DNA slot blot hybridization (P. Besse et al., 1997[1]). This step verifies that plants are indeed hybrid. In the second step, flow cytometry is used to roughly quantitate DNA in the hybrids, permitting a relative measure of chromosome number among sugarcane hybrids. Flow cytometry was used to assign 304 plants of *Pennisetum* sect. *Brevivalvula* Stapf & Hubbard to one of four ploidy levels, i.e., 2n = 2x = 18, 2n = 4x = 36, 2n = 5x = 45, or 2n = 6x = 54 (Renno et al., 1995). Whether classical or molecular tools are used, the potential value of 2*n*+*n* progeny to sugarcane breeding seems sufficient to warrant further research.

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Table 1. Chromosome number, chromosome transmission, and cytological analyses of various sugarcane hybrids.

Cross / clone[a]	Generation	Cells	Mean 2*n* number[b]	Mean meiotic pairing[c]				TII micro-nuclei
				I	II	III	IV	
		(no.)				(%)		(no.)
1. NCo 310 (2*n*=112[10]) x US 56-42-3 *Miscanthidium violaceum* (2*n*=28[24])								
US 87-1023	F_1	11	97	5.81	92.21	1.98	0.00	2.60
13-2	F_2	18	95	4.09	93.92	1.77	0.25	1.54
13-6	F_2	4	94.8 (93-96)	4.22	93.93	0.79	1.06	ND
13-10	F_2	17	94	3.19	95.87	0.93	0.00	2.20
13-13	F_2	9	96	2.90	96.06	1.03	0.00	2.72
2. NCo 310 (2*n*=112[10]) x IMP 3905 *Miscanthus sinense* (2*n*=38[8])								
65-2	F_2	13	92	2.34	96.65	0.00	1.00	2.16
65-4	F_2	25	90.7 (87-96)	2.60	97.22	0.00	0.18	2.20
65-6	F_2	21	91.9 (90-93)	4.09	95.58	0.33	0.00	3.12
3. NCo 310 (2*n*=112[10]) x US 47-11 *M. sinense* (2*n*=38[8])								
US 87-1020	F_1	18	94	3.37	94.68	1.95	0.00	3.46
US 87-1021	F_1	14	94	6.00	90.26	2.52	1.23	7.34
236-14	F_2	9	110.3 (110-113)	4.43	94.27	0.90	0.40	0.80
236-21	F_2	13	108	11.19	87.89	0.64	0.30	4.44
4. POJ 2725 (2*n*=107[17]) x *M. japonicus* (2*n*=38[17])								
PT 33-85	F_1	10	75	5.47	81.87	7.60	5.07[d]	8.72
5. CP 65-357 (2*n*=104-115[10]) x IS 76-178 *Erianthus arundinaceus* (2*n*=60[1])								
US 87-1016	F_1	10	103	1.75	97.67	0.58	0.00	2.86
US 87-1017	F_1	6	100	1.67	98.34	0.00	0.00	2.74

Table 1. Continued.

Cross / clone	Generation	Cells	Mean 2*n* number	Mean meiotic pairing				TII micro-nuclei
				I	II	III	IV	
		(no.)				(%)		(no.)
347-1	BC_1	13	100.8 (100-103)	13.80	85.28	0.92	0.00	3.34
347-2	BC_1	10	104	7.88	89.81	2.31	0.00	3.26
347-5	BC_1	21	106.0 (102-108)	4.23	94.90	0.68	0.19	1.97
347-6	BC_1	16	103.6 (100-109)	5.20	93.30	1.27	0.23	1.26
6. CP 65-357 (2*n*=104-115[10]) x SES 273 *E. elephantinus* (2*n*=20[8,18])								
US 82-44	F_1	11	101	6.84	91.27	1.90	0.00	4.94
7. CP 79-348 (2*n*=112[10]) x NG 77-199 *Saccharum robustum* (2*n*=166[8])								
US 94-97	F_1	8	129.4 (114-137)	7.92	89.86	1.44	0.77	2.76
8. POJ 2222 (2*n*=107[this study]) x Open pollinated *S. spontaneum*								
US 94-82	F_1	11	80	3.41	96.58	0.00	0.00	4.10
US 94-83	F_1	10	80.1 (79-82)	3.50	96.13	0.37	0.00	3.36
US 94-84	F_1	10	84	6.07	90.95	2.50	0.48	3.92
9. CP 65-357 (2*n*=104-115[10]) x Open pollinated *S. spontaneum*								
US 94-87	F_1	8	85.8 (82-88)	6.12	91.23	0.87	1.77	4.44[e]
10. HoCP 91-534 (2*n*=100[this study]) x Open pollinated *S. spontaneum*								
US 94-93	F_1	6	80.2 (76-83)	7.48	91.88	0.64	0.00	ND[f]
11. CP 79-332 (2*n*=112-114[this study]) x Self								
US 94-51	F_2	10	115	3.04	96.70	0.26	0.00	3.96

Table 1. Continued.

Cross / clone	Generation	Cells	Mean $2n$ number	Mean meiotic pairing				TII micro-nuclei
				I	II	III	IV	
		(no.)				(%)		(no.)
12. LCP 85-384 $(2n=106^{\text{this study}})$ x Self								
US 94-71	F_2	11	108	3.79	93.94	1.25	1.00	2.08
US 94-72	F_2	11	111.7 (109-112)	5.05	94.71	0.24	0.00	0.88
13. CP 88-772 x Self								
US 94-74	F_2	7	116	11.82^{g}	88.17	0.00	0.00	1.60
14. HoCP 88-739 $(2n=111\text{-}113^{\text{this study}})$ x Self								
US 94-75	F_2	4	112.8 (112-113)	3.77	96.23	0.00	0.00	5.24
15. CP 57-614 $(2n=100^{\text{this study}})$ x Self								
US 94-76	F_2	11	109.4 (103-112)	3.82	96.18	0.00	0.00	ND
US 94-77	F_2	6	110	1.97	96.67	1.36	0.00	1.08
US 94-78	F_2	4	110	3.64	95.00	1.36	0.00	1.76
16. Katha *S. sinense* $(2n=91^{25})$ x SES 372 *E. elephantinus* $(2n=20^{8})$								
US 94-64	F_1	18	86.5 (86-92)	3.60	95.82	0.59	0.00	2.48
17. Louisiana Purple *S. officinarum* $(2n=80^{2})$ x Molokai 5829 *S. robustum* $(2n=80^{23,\text{ this study}})$								
H 91-9004	F_1	10	80	0.00	100.00	0.00	0.00	0.24
H 91-9007	F_1	25	80	0.00	100.00	0.00	0.00	0.18
H 91-9011	F_1	18	80	0.00	100.00	0.00	0.00	0.00
H 91-9040	F_1	16	80	0.00	100.00	0.00	0.00	0.12

Table 1. Continued.

Cross / clone	Generation	Cells	Mean 2*n* number	Mean meiotic pairing I	II	III	IV	TII micro-nuclei
		(no.)				(%)		(no.)
H 91-9048	F_1	9	80	0.84	99.18	0.00	0.00	0.08
H 91-9151	F_1	17	80	0.00	100.00	0.00	0.00	0.44
18. Green German *S. officinarum* (2*n*=102-117[this study]) x IND 81-146 *S. spontaneum* (2*n*=56[29, this study])[h]								
GxI No. 2	F_1	6	81.3 (73-84)					
GxI No. 3	F_1	2	84.0 (83-85)					
GxI No. 4	F_1	5	78.8 (77-83)					
19. PIN 84-1 *S. spontaneum* (2*n*=96[this study]) x Muntok Java *S. officinarum* (2*n*=138-144[this study])[h]								
PxM No. 1	F_1	4	113.0 (108-121)					
PxM No. 2	F_1	6	109.8 (99-117)					
PxM No. 3	F_1	4	112.0 (107-119)					

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[a] References for chromosome counts of parental clones are in superscripts

[b] Chromosome counts were approximate in some clones or varied due to mosaicism.

[c] I = univalent, II = bivalent, III = trivalent, and IV = quadrivalent.

[d] Includes one hexavalent.

[e] Mean micronuclei frequency at telophase I.

[f] Microsporocytes degenerated prior to telophase II.

[g] Premature disjunction of bivalents.

[h] Chromosome counts for these parents and progeny were determined at mitotic metaphase.

PREDICTING MARKET SURVIVAL OF SUGARCANE CULTIVARS

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ABSTRACT

Sugarcane in Florida is grown in the northern Everglades adjacent to Lake Okeechobee. Since 1931, thirty-three principal cultivars have occupied greater than 1% of the acreage for at least one year. This paper describes how market diversity varies from year to year, predicts cultivar longevity based on factors measured soon after release (within 6 years), and examines how sugarcane cultivars can be rated based on their survival. Market longevity is a measure of the cultivar's value. Factors that influence cultivar decline in the market include decreases in vigor and yield, increase in disease susceptibility, reaction to newly-introduced diseases, and improvement in yield of newly-released cultivars. However, because these factors often cannot be identified soon after a cultivar's release and may change due to edaphic or environmental conditions throughout the cultivar's market life, they are difficult to use for predicting how long the cultivar will remain in the market. This paper describes a cultivar survival analysis method using readily available market information that enable direct comparisons of historic and current cultivars.

Key words: Censored observations, Cox regression, Florida, Kaplan-Meier, Simpson Diversity Index, Survival analysis.

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INTRODUCTION

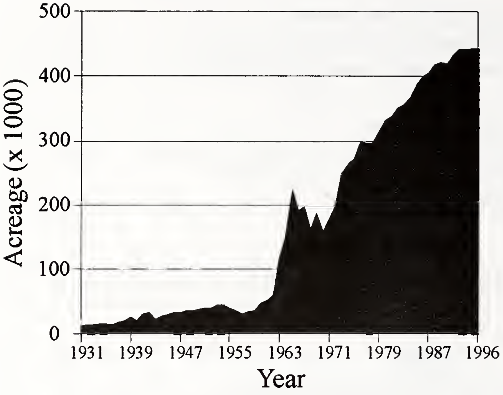

Figure 1. Total sugarcane acreage in south Florida, 1931-1995.

By 1493, sugarcane was established in the New World by Columbus and other Spanish explorers. From the early 1800s until the 1920s, numerous small plantations and mills existed for short periods in Florida (Anderson and Rosendahl, 1996). Since the 1930s, the amount of sugarcane grown in south Florida has increased (Figure 1) as has the number of associated mills (Table 1). Total acreage remained static through the 1950s. From 1959-1962, the establishment of the Castro government in Cuba led to a mass exodus of sugar technologists to Florida. The United States lifted acreage restrictions and disallowed an import quota of sugar from Cuba, permitting expansion of the sugar industry (Alvarez, 1978; Polopolus and Alvarez, 1991) from over 35,000 acres in 1955 to over 450,000 acres in seed and harvest sugarcane in 1995. There was a small decline in acreage in the late 1960s and early 1970s as quotas on production were imposed and production shifted to vegetable crops. Production has stabilized in the last five years (Figure 1), because acreage in sugarcane in the Everglades Agricultural Area (EAA) has reached its limit. Recent growth in sugarcane acreage is on sandland areas adjacent to the EAA.

Table 1. Brief history (65 years) of Florida sugar companies.

Year	Founded/Closure
1931	U.S. Sugar Corp. — Clewiston
1933	Fellsmere Sugar Co.
1937	Fellsmere Sugar Producers Association
1947	Okeelanta Sugar Corp.
1959	Closure of Fellsmere Sugar Producers Association
1961	Florida Sugar Corp.
1961	Osceola Farms Co.
1962	U.S. Sugar Corp. — Bryant
1962	Glades Co. Sugar Growers Coop. Assoc.
1962	Sugarcane Growers Coop. of Florida
1962	Talisman Sugar Corp.
1963	South Florida Sugar Co.
1964	Atlantic Sugar Assoc. Coop.
1965	Everglades Sugar Refinery, Inc.
1971	Closure of Florida Sugar Corp.
1977	Closure of Glades Co. Sugar Growers Coop. Assoc.

Market share can be defined as the ratio of the individual cultivar's release acreage to the total acreage in sugarcane production. Cultivars attaining greater than 1% of the market had a great diversity in longevity and market share (Figure 2). From 1931 to 1961, only four principal cultivars (POJ 2725, F31-962, F31-436, and CL41-223) were available to growers. These cultivars had a tendency to acquire a large market share soon after release and maintain it for a long period of time. As total acreage increased in the mid-1960s to include areas with varying soil types and climate, an increased number of new cultivars were released for commercial production. Since the mid-1960s, the number of cultivars in production has remained high, and in 1995, 13 principal cultivars were grown (Glaz, 1995).

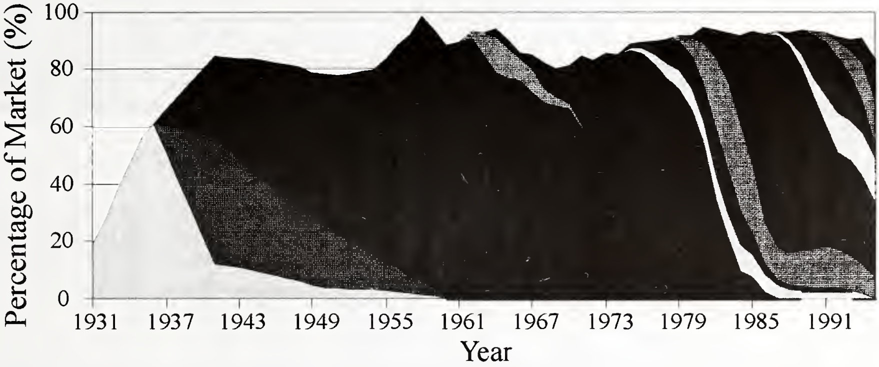

Figure 2. Market share of Florida sugarcane cultivars, 1931-1996.

The objectives of this research were (1) to describe historic Florida sugarcane cultivar market patterns, (2) to predict survival times of historic and current principal cultivars using descriptive measures over time (Lee, 1992), and (3) to develop cultivar performance categories based on predicted survival times that can be used to compare similarities/differences between historic and current cultivars. Survival analysis has been traditionally used to predict survival times of individuals (ie., patients after treatment, mechanical parts in an engine, insects after treatment with insecticide, etc.; Lee, 1992). To the authors knowledge, the use of survival analysis to predict how long a cultivar will stay in the market has not been done. Results of this research will be useful for understanding the importance of cultivar development and market diversity. In working with databases containing cultivars that have left the market, the performance ratings developed from this research will be useful for comparison of similar cultivars from the past to those currently in the market.

METHODS

The number of sugarcane acres planted and cultivars grown in south Florida each year were obtained in unpublished data (1928-1995) from the Florida Sugar Cane League (Clewiston, FL USA) and from annual cultivar census reports (1930-1995) published by USDA-ARS (Sugarcane Field Station, Canal Point, FL USA) and Sugar y Azucar (Ruspam Communications, R.E. Slimermeyer (publisher), Englewood Cliffs, NJ 07632). To describe the trends in cultivar diversity, the Simpson's Diversity Index (SDI) was calculated annually from 1931 to 1995 (Simpson, 1949). The SDI ranges from 0.00 (indicating no diversity) to 1.00 (indicating high diversity).

Cultivar diversity data prior to 1960 were quite different from later years (Figure 2), hence only the 29 principal cultivars released after 1960 were used for market survival analysis. Survival time for a cultivar is defined as the number of years that a cultivar was in production with a market share of greater than 1% (Table 2). The 1% cutoff was used because data limitations did not allow identification of cultivars with smaller market shares. Of the 29 principal cultivars, 16 cultivars no longer carried a 1% share of the market by 1995. For these cultivars, survival times were known. The remaining 13 principal cultivars were still in the market in 1995; hence, their survival times are not yet known. These cultivars were defined as "censored." In survival analysis, the probability of an individual (in this case a cultivar) surviving beyond a given age is estimated by a survival function. To account for the censored survival times, the Kaplan-Meier product-limit method (Kaplan and Meier, 1958; Lee, 1992) of estimating a survival function was used. A 95% confidence bound for the survival function was determined using linear interpolation of the upper and lower bounds of the 95% confidence intervals that utilized Greenwood's variance formula for each of the estimated survival probabilities (Greenwood, 1926; Lee, 1992). This approach allowed estimation of a median survival time for the 29 principal cultivars.

Table 2. Principal sugarcane cultivars grown in Florida from 1931-1995.

Cultivar	Years grown	Observed survival (yr)	Predicted survival (yr)	Cultivar	Years grown	Observed survival (yr)	Predicted survival (yr)
POJ 2725[‡]	1931-1959	29	na[§]	CL65-294	1980-1982	3	3
F31-962[‡]	1936-1959	24	na	CL61-620[†]	1981-1995	15	16
F31-436[‡]	1936-1963	28	na	CL68-575	1981-1984	4	3
CL41-223[‡]	1950-1981	32	na	CL41-191	1981-1983	3	3
CP50-28	1962-1971	10	9	CP72-1210[†]	1982-1995	14	>20
CL47-83	1964-1971	8	13	CP73-1547[†]	1983-1995	13	8
CL54-336	1969-1982	14	12	CP74-2005	1984-1991	8	15
CP57-603	1969-1982	14	12	CP72-2086[†]	1987-1995	9	17
CP56-59	1969-1983	15	14	CL73-239[†]	1988-1995	8	17
CP63-588	1970-1985	16	15	CL69-886[†]	1989-1995	7	8
CL54-378	1971-1986	16	15	CP78-2114[†]	1989-1995	7	15
CP62-374	1971-1982	12	12	CP80-1827[†]	1990-1995	6	>20
CL59-1052	1975-1994	20	16	CP80-1743[†]	1992-1995	4	18
CL61-5	1975-1983	9	9	CP81-1254[†]	1993-1995	3	4
CP65-357	1977-1991	15	>20	CL72-321[†]	1994-1995	2	6
CL65-260	1977-1982	6	8	CP78-1628[†]	1994-1995	2	12
CP70-1133[†]	1979-1995	17	>20				

[†] Cultivar still used in the industry (censored observation).

[‡] Cultivar not included in survival analysis.

[§] Predicted survival time not estimated since cultivar was not included in survival analysis.

In an attempt to obtain better estimates of median survival time for each principal cultivar, the influence of cultivar covariates on the survival model was examined. The covariates tested for significant effects on the survival curve were:

market share in first year of lifetime (MS_{Y1}),
maximum market share in first 4 years of lifetime (MMS_{Y4}),
maximum market share in first 5 years of lifetime (MMS_{Y5}),
maximum market share in first 6 years of lifetime (MMS_{Y6}),
Simpson's Diversity Index in the first year of lifetime (SDI_{Y1}),
year cultivar entered the market (YR),
market average raw sugar/ton cane in first year ($SPTC_{Y1}$),
market average tons cane/acre in first year (TPA_{Y1}), and
market average sugar/acre in first year (SPA_{Y1}).

Survival models developed by Cox (Cox, 1972; Lee, 1992) were fit to the data using the above covariates alone and in combinations as follows:

$$S(t)=[S_0(t)]^{\exp(\sum_{i=1}^{k}\beta_i x_i)} \qquad (1)$$

where: $S(t)$ = probability of surviving beyond time t,
$S_0(t)$ = baseline probability of surviving beyond time t,
β_i = coefficient for the i^{th} covariate, and
x_i = i^{th} covariate.

A stepwise selection procedure with entry and removal significance levels set at $\alpha=0.05$ was used to search for the "best-fit" model. The final model was selected based on the maximum R^2 value (Nagelkerke, 1991) and confirmed using diagnostic plots. Predicted survival functions were calculated for each cultivar using only the final selected survival model. Median survival times for each cultivar were estimated from these Cox survival functions. All computations for the Kaplan-Meier curves, stepwise Cox models, and diagnostic plots were performed using the statistical analysis package S-Plus 3.3 (Venables and Ripley, 1994).

RESULTS AND DISCUSSION

Changes in cultivar diversity were evident through the use of annual SDI (Figure 3). From 1931 to 1936, SDI was 0 since only one principal cultivar, POJ 2725, was grown. From 1937 through the mid-1950s, diversity was high, as each cultivar had an approximately equal share of the total acreage. In the early 1960s, CL41-223 dominated the market, therefore, SDI was low. But as CL41-223 lost popularity and other cultivars entered the market, SDI increased. The market tended to maintain a high diversity through 1995, with a small decrease in the late 1980s as CP72-1210 dominated the market with a market share of 61% in 1987.

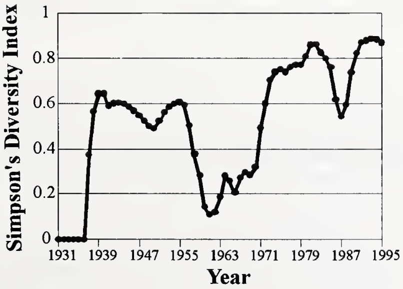

Figure 3. Annual Simpson's Diversity Index, 1931-1995.

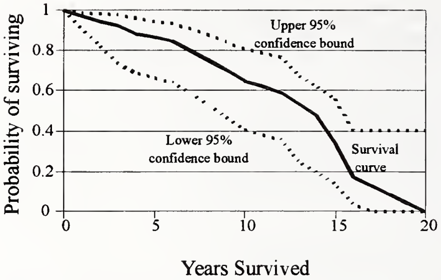

Figure 4. Kaplan-Meier survival curve for Florida sugarcane cultivars.

The survival probability as estimated by the Kaplan-Meier product-limit technique decreased at a constant rate as the years of survival increased (Figure 4). Median survival time of all principle cultivars released during 1961 to 1995 was estimated at 14 years. Estimating the overall survival curve and the median survival time did not provide an adequate description of how changes in the market influenced cultivar survival times.

The stepwise Cox regression tested potentially influential factors (covariates) influencing cultivar survival. Only SDI_{Y1}, $\ln(MMS_{Y6})$, and their interaction significantly improved model fit (Table 3). Predicted survival times for each of the 29 cultivars used in the survival analysis were calculated from the selected Cox model (Table 2).

Table 3. Parameters for the selected Cox regression model (R^2=0.563).

Covariate	Parameter estimate	Standard error	P-value
SDI_{Y1} †	7.24	3.48	0.037
$\ln(MMS_{Y6})$ ‡	1.05	0.93	0.260
SDI_{Y1} x $\ln(MMS_{Y6})$	-5.76	0.21	0.006

† Simpson's Diversity Index in the first year of lifetime.

‡ maximum market share in the first 6 years.

The Cox model was interpreted by comparing survival curves for specific covariate values (Figures 5a,b). When a cultivar was released in a market of low diversity (SDI_{Y1} = .40) and attained only a small market share in its first 6 years (MMS_{Y6} = 2%), the predicted survival time was 9 years. However, if under similar diversity conditions the cultivar attained a larger portion of the market in its first 6 years (MMS_{Y6} = 10%), the predicted survival time was 15 years. When cultivars were released in a market with high diversity (SDI_{Y1} = .80), there was a large difference in predicted survival times of cultivars with a small MMS_{Y6} and cultivars with a large MMS_{Y6}. Cultivars in a highly diverse market with MMS_{Y6} = 2% had a predicted survival time of 6 years, while cultivars in a highly diverse market with MMS_{Y6} = 10% had predicted survival times of greater than 20 years. Based on this model, cultivars which have long survival times are those released in a diverse market and that obtain a large share of the market in the first 6 years of production.

Two recently released cultivars, CP81-1254 and CL72-321, were predicted to be in the market for a very short time (4 and 6 years, respectively). Model predictions may be misleading for these two cultivars, as they have only been in the market for two or three years, and the covariate MMS_{Y6} is based on 6 years. Since these two cultivars were released in a time of high market diversity, their predicted survival times would be greater based on this model if their popularity continues to grow over the next several years.

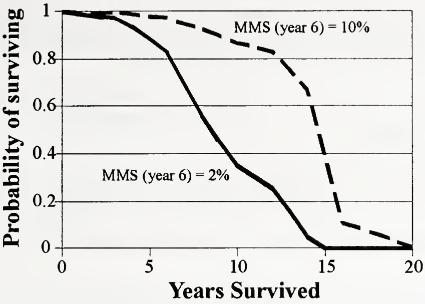

Figure 5a. Survival curves for cultivars released when SDI (year 1) = 0.40.

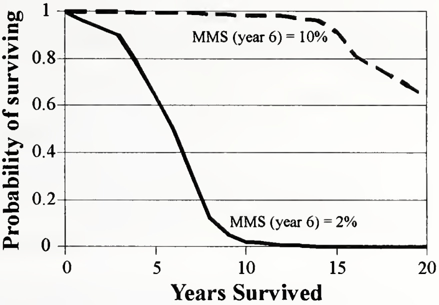

Figure 5b. Survival curves for cultivars released when SDI (year 1) = 0.80.

Three cultivar market performance categories were formed, based on predicted survival times (Table 4): 4 cultivars had predicted survival times greater than 20 years (high market performance); 15 cultivars had predicted survival times of 12 to 18 years (moderate market performance); and 13 cultivars had predicted survival times less than 10 years (low market performance). These categories placed both historic cultivars no longer in the market together with currently used cultivars; therefore, historic cultivars could be compared to current cultivars. When a cultivar survived many years in the market, its performance was considered to be favorable and thus it was accepted by the industry.

Table 4. Market performance categories of Florida sugarcane cultivars.

High Market Performance - predicted survival > 20 years			
CP65-357	CP70-1133†	CP72-1210†	CP80-1827†
Moderate Market Performance - predicted survival 12-18 years			
CL47-83	CL54-336	CP57-603	CP56-59
CP63-588	CL54-378	CP62-374	CL59-1052
CL61-620†	CP74-2005	CP72-2086†	CL73-239†
CP78-2114†	CP80-1743†	CP78-1628†	
Low Market Performance - predicted survival ≤ 10 years			
CP50-28	CL61-5	CL65-260	CL65-294
CL68-575	CL41-191	CP73-1547†	CL69-886†
CP81-1254†	CL72-321†		

† Cultivar still used in the industry (censored observation).

For some cultivars with known survival times, such as CL47-83 and CP73-1547, the model did not do a good job of predicting survival time. Factors, such as initial yield estimates, disease resistance, weather, and soil quality may have attributed to the lack of fit of this model. If these variables had been included as covariates in the Cox regression, the model may have done better at explaining variability in survival times. However, because these factors often cannot be identified soon after a cultivar's release and may change due to edaphic or environmental conditions throughout the cultivars market life, they are difficult to use for predicting how long the cultivar will remain in the market.

CONCLUSIONS

Sugarcane cultivar diversity in south Florida has fluctuated greatly since the 1930s, as measured by Simpson's Diversity Index. However, since the 1970s, cultivar diversity was consistently high, except when CL41-223 dominated the market for a brief time in the late 1980s.

Cultivar longevity is positively influenced by high diversity during the year of release and acquisition of a large share of the market in the first several years after release. Therefore, high diversity is a desirable market characteristic leading to increased cultivar longevity. The 29 Florida sugarcane cultivars released after 1960 are categorized into three performance categories based on predicted survival times. This market analysis method helps growers assess the risk associated with continuing to grow a particular cultivar by enabling them to make direct comparisons of historic and current cultivars.

The survival analysis methods used to develop this model are applicable in other regions where sugarcane is grown. If comparable data are available, survival analyses could also be conducted that combine and compare cultivar information from several regions.

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TOLERANCE OF SUGARCANE CULTIVARS TO THE HERBICIDES ASULAM AND TERBACIL

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ABSTRACT

Recently-released Louisiana sugarcane cultivars (*Saccharum* interspecific hybrids) LCP 82-89, LHo 83-153, HoCP 85-845, LCP 85-384, and LCP 86-454 were compared with older cultivars CP 72-370 and CP 74-383 or CP 70-321 for tolerance to asulam (ASULOX) postemergence (June application) and nondirected soil treatments of terbacil (SINBAR), either when applied only in the plant-cane crop or in both the plant-cane and following ratoon crops. The relative tolerance to certain herbicides becomes an important characteristic of a cultivar. The magnitude of the response of individual cultivars to asulam and terbacil, as measured by cane and sugar yield, varied among experiments, but none of the newer cultivars were consistently less tolerant than CP 72-370, which is known to be relatively sensitive to both herbicides. Asulam caused some reduction in cane yield of both newer and older cultivars, usually in the range of 5% to 10%, which probably was influenced by the June application since earlier spring applications are known to be generally less phytotoxic. Terbacil also reduced cane yields, usually in the range of 5% to 12%, but much larger reductions occurred occasionally in plant-cane experiments on silty loam soils having relatively low organic matter (1.3% to 1.6%) and/or clay (10% to 14%), thus low adsorptive capacity. However, the newer cultivar LHo 83-153 had relatively good tolerance to terbacil on the same type of soil, being much more tolerant than older cultivar CP70-321, and generally appeared to be one of the most herbicide-tolerant cultivars. The study indicated that careful management will be needed when using asulam and terbacil on most of the newer cultivars, similar to practices now being used with CP 72-370.

INTRODUCTION

In Louisiana, herbicides are used extensively in sugarcane to control johnsongrass [*Sorghum halepense* (L.) Pers.], itchgrass [*Rottboellia cochincinenesis* (Lour.) Clayton] , annual morningglory (*Ipomoea* sp.), and a wide range of other grass and broadleaved weeds, and are an integral part of an efficient sugarcane production system. Over-the-top applications of asulam (methyl [(4-aminophenyl) sulfonyl] carbamate) can be used effectively for postemergence control of johnsongrass and itchgrass, usually without significant injury to sugarcane (Millhollon,1976a and 1986a; Richard, 1990). Likewise, nondirected, soil treatments with terbacil [5-chloro-3-(1,1-dimethylethyl)-6-methyl-2,4-(1H,3H)-pyrimidinedione], metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one], and pendimethalin [N-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine] can provide effective preemergence control of seedling johnsongrass and many other weeds, but sugarcane injury is more likely with terbacil (Millhollon, 1976b and Richard, 1989) than with metribuzin (Millhollon, 1977) or pendimethalin (Millhollon, 1993).

In a typical farming operation, three or more cultivars of sugarcane are grown to take advantage of the best qualities of each. Older cultivars that are still being grown can vary in response to herbicides: CP 65-357, CP 70-321, and CP 74-383 were more tolerant than CP 72-

370 to asulam; CP 72-370 and CP 65-357 more tolerant than CP 70-321 to dalapon [2,2-dicholropropanoic acid] (Millhollon and Fanguy, 1989); CP 74-383 more tolerant than CP 65-357, CP 72-370, and CP 70-321 to terbacil (Richard, 1989); and CP 74-383 and CP 70-321more tolerant than CP 65-357 and CP 72-370 to hexazinone [3-cyclohexyl-6-(dimethylamino)-1-methyl-1,3,5-triazine-2,4(1H,3H)-dione] (Millhollon, 1986b; Richard, 1989). The degree of tolerance to herbicides becomes an important characteristic of a cultivar, and the purpose of this study was to compare newer and older cultivars for response to asulam and terbacil, which are more likely than other available herbicides to cause a differential response in cultivars.

MATERIALS AND METHODS

A series of cultivar by herbicide factorial experiments, either complete factorials arranged in randomized complete blocks or split-plots with sub units in randomized complete blocks, were conducted at the USDA, ARS Sugarcane Farm near Houma, Louisiana on silty loam soil (Typic Fluvaquent; fine-silty, mixed, nonacid, thermic). The soil in most experiments had 1.5% to 1.8% organic matter and 16% to 24% clay, but variations occurred and are noted for the experiments involved. The newer cultivars LCP 82-89, LHo 83-153, HoCP 85-845, and LCP 85-384 had been released for planting during the period 1990 to 1994. The older cultivars CP 72-370 and CP 74-383 were primarily used for comparison, based on general knowledge of their herbicide tolerance, which ranged from least to most tolerant, respectively. Cultivar CP 70-321 was also used for comparison in some experiments because it is currently the most widely-grown cultivar in Louisiana. Herbicide treatments usually began in the fall-planted, first-yr crop (plant cane) and in many experiments continued into the second- and third-yr crops (ratoons).

Herbicide treatments were similar in those experiments that included both asulam (ASULOX) and terbacil (SINBAR). Asulam at 3.7 kg/ha was applied over-the-top of sugarcane during June in plant-cane crops and, when the study continued for 3 years, reapplied during June in the ratoon crops. A June application rather than an earlier date was chosen because this is the period when asulam is generally most phytotoxic to sugarcane in Louisiana. Terbacil was applied as sequential, nondirected soil treatments: 1.8 kg/ha after planting in fall, 2.2 or 2.7 kg/ha in the following March or early April in the plant-cane crop, and, when the study continued for 2 or 3 years, reapplied at 2.7 kg/ha during March or early April in the ratoon crop(s). Terbacil is labelled for use at broadcast rates of 1.8 kg/ha fall and spring in the plant-cane crop and 3.6 kg/ha spring in each ratoon crop, but in this study the spring rate for plant-cane was increased to better characterize the herbicide-tolerance of cultivars. Conversely, terbacil rates were reduced below the label for ratoon crops to maintain spring rates at about the same level for all crops. Herbicides were applied in water sprays at 374 L/ha to a 91-cm band over rows spaced 1.7-m apart; a 0.25% (v/v) nonionic surfactant[1] was added to asulam solutions. Terbacil and asulam were applied when sugarcane height was 25 to 35 cm and 135 to 155 cm, respectively. Plots devoted to asulam treatments and weed-free controls received an application of metribuzin at 1.6 kg/ha after planting and during March or April of each following year to provide preemergence weed control. Metribuzin is considered relatively nonphytotoxic to sugarcane since very high rates in early spring have not injured sugarcane in Louisiana (Millhollon, 1977). All plots received supplementary hand weeding when required to maintain them free of weeds.

Other treatment variables specific to individual experiments were as follows:

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[1] TRITON AG-98 (a proprietary name is necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.)

LCP 82-89

Three experiments were conducted; the first two primarily involved standard asulam and terbacil treatments and cultivars CP 72-370 and CP 74-383 for comparison, and the third involved only asulam treatments and CP 70-321 for comparison. The first experiment , plots 3-rows wide by 8 m long with 3 replicates, was conducted only in the plant-cane crop (1988 to 1989) and also included LHo 83-153 which was being considered for release at that time. The second experiment, plots 3-rows wide by 8 m with 5 replicates, was conducted during a complete 3-yr crop cycle (1990 to 1993) and included a treatment in which terbacil was applied only in the two ratoon crops with metribuzin at 1.6 kg/ha replacing terbacil in the plant-cane crop. In the third experiment, plots 3-rows wide by 8 m with 8 replicates, asulam was applied at monthly intervals from late April to June in the first-ratoon crop in 1992 and reapplied in the second-ratoon crop in 1993.

LHo 83-153

Three experiments were conducted; the first two involved standard asulam and terbacil treatments and the third only terbacil treatments. The first experiment, conducted in plant-cane, was the same as the first experiment described for LCP 82-89 above. The second experiment, plots 3-rows wide by 9 m with 4 replicates, was conducted during a 3-yr crop cycle (1990 to 1993) and included CP 72-370 for comparison. In the third experiment, conducted at two locations with CP 70-321 for comparison, terbacil at 2.2 kg/ha, approximate use rate, and 4.4 kg/ha was applied to a plant-cane crop and, in separate plots, to a ratoon of that crop. At location 1, plots 3-rows wide by 8 m with 5 replicates, terbacil treatments were applied to plant cane during April, 1992, and to the first-ratoon during April, 1993. At location 2, plots 1-row wide by 10 m with 6 replicates, terbacil was applied to plant cane during April, 1993, and to the second-ratoon during April, 1995. Plots which received terbacil in a ratoon crop were treated with metribuzin at 1.6 kg/ha in the preceeding crop(s). The soil at both locations was a silty loam with 1.6% organic matter, but the clay content varied, 16% at location 1 compared to 14% at location 2.

CP 85-845 and LCP 85-384

Two experiments were conducted, both involving standard asulam and terbacil treatments and CP 72-370 and CP 74-383 for comparison. The first experiment, plots 1-row wide by 8 m with 3 replicates, was conducted only in the plant-cane crop (1989 to 1990) whereas the second experiment, plots 3-rows by 8 m with 5 replicates, was conducted during a 3-yr crop cycle (1991 to 1994). The soil in both experiments was a silty loam with 1.3% organic matter and 10% clay for the first experiment and 1.4% organic matter and 12% clay for the second.

LCP 86-454

In the single experiment (plots 1-row wide by 9 m with 4 replicates), standard asulam and terbacil treatments were applied during the first two crops, plant cane and first ratoon (1990 to 1992), of a 3-yr crop cycle with CP 72-370 and CP 74-383 for comparison.

Plots were harvested with a whole-stalk harvester that cut stalks at ground level and removed leafy tops. Stalks were then burned to remove dried leafy trash and weighed; stalk weight was determined from total weight of stalks/plot divided by their number, based on stalk population in September prior to harvest. A 15-stalk sample from each harvested plot was crushed once in a three-roller sample mill, and the juice analyzed for Brix using standard methods (Chen and Chou, 1993). The yield of theoretical recoverable sugar per kg. cane (TRS) was calculated by methods previously described (Legendre and Henderson, 1972) and used to calculate yield of sugar/ha (cane/ha x TRS). Data were analyzed according to standard analysis of variance methods for factorial experiments and least significance difference (LSD, $P = 0.05$) was used for mean separation. Cane and sugar yields were used as the primary quantitative measure of the tolerance of cultivars to herbicide treatments. In a 2- or 3-yr crop cycle, yield data was analyzed statistically for each crop in the cycle, using a pooled error mean square from each crop, and also for total yield during the cycle (mean annual yield).

RESULTS AND DISCUSSION

The visible response of sugarcane cultivars to asulam was similar in the various experiments: about two weeks after treatment leaves became slightly to moderately chlorotic, CP 72-370 usually having the most pronounced symptoms, but new growth of sugarcane appeared normal. Terbacil caused very little visible injury in most experiments, usually in the form of slightly stunted growth and stand reduction, but the occassionally more severe injury was manifested by leaf chlorosis for an extended period and stunted growth, ranging from moderate to severe. Yield data for a 3-yr crop cycle is presented for each crop and as a mean for all three crops (mean annual yield).

LCP 82-89

When LCP 82-89 and LHo 83-153 were compared with CP 72-370 and CP 74-383 for response to herbicides in a plant-cane experiment, no cultivar by treatment interaction was found for cane and sugar yields (Table 1). However, both asulam and terbacil reduced cane yield below the control, as a mean of all cultivars, by 7% and 12%, respectively. Yield reductions were primarily the result of reduced stalk population with no significant reduction in stalk weight (data not presented). The corresponding sugar yields also were generally lower than control. In the plant-cane crop of the 3-yr experiment, both asulam and terbacil also reduced cane yield of all cultivars, and caused large decreases in sugar yield (Table 2). The periodic flooding in this crop by heavy summer rains and slow surface drainage probably contributed to the yield reductions. Asulam and terbacil treatments, together with the flooding, reduced TRS below controls about equally and more in CP 72-370 (6 to 7%) and CP 74-383 (11%) than in LCP 82-89 (no yield reduction) (data not presented), and these reductions in TRS were largely responsible for the apparently greater loss in sugar yields for CP 72-370 and CP 74-383 than LCP 82-89. Asulam treatments in the ratoon crops also reduced cane and sugar yield of all cultivars, resulting in an overall 9% reduction in mean annual yield of both cane and sugar during the 3-yr crop cycle. Terbacil applied annually beginning in the plant-cane crop (terbacil-A) was about equally phytotoxic to cultivars as asulam in the plant-cane and first-ratoon crops but caused no yield reduction, as compared to the control, in the second-ratoon crop. The annual application of terbacil caused a 4% and 5% reduction in mean annual cane and sugar yield, respectively. The terbacil-B treatment, which was applied only in the ratoon crops, produced mean annual cane and sugar yields that were comparable to those in the control and greater than those in terbacil-A, indicating that much of the injury by terbacil was avoided by limiting treatment to ratoon crops. As observed in the first experiment, reductions in cane yield by both asulam and terbacil were primarily caused by decreases in stalk population (data not presented).

In the application timing study, asulam had about the same effect on cultivars in the first-ratoon as in the second-ratoon crop; therefore, results are presented only as mean annual yields for the two crops (Table 3). LCP 82-89 showed no yield reduction from April or May appplications but had a 10% reduction in cane and sugar yields from a June application. In contrast, CP 70-321 had no yield reduction from any asulam treatment. In a previous cultivar-herbicide study, Millhollon and Fanguy (1989), found that CP 70-321 was somewhat more tolerant to asulam than CP 72-370 which is generally considered the most sensitive cultivar to this herbicide. An application of asulam in April or early May, rather than June, is generally less phytotoxic to sugarcane and controlls johnsongrass more effectively, thus a June application usually is not needed (Millhollon, 1976a; Richard, 1990). The data from these three experiments indicate that LCP 82-89 can be injured by both asulam and terbacil, but did not show that it was excessively sensitive as compared to older cultivars.

LHo 83-153

As described above, asulam and terbacil treatments in plant cane caused some reduction in cane yield of LHo 83-153 similar to LCP 82-89, CP 72-370, and CP 74-383 (no interaction) (Table 1). However, in the second experiment, LHo 83-153 was generally more tolerant than CP 72-370 to both asulam and terbacil applied during a 3-yr crop cycle as shown by the significant cultivar by herbicide interaction for mean annual cane and sugar yield (Table 4). In the third experiment, LHo 83-153 was much more tolerant than CP 70-321 to terbacil, both at the 2.2 kg/ha use rate and a double rate, as measured by cane yield (Figure 1). Terbacil was generally more phytotoxic to both cultivars in plant cane than ratoon cane and at location 2 than location 1. In the plant-cane crop, terbacil at 2.2 kg/ha caused cane yield reductions of 0% and 11% for LHo 83-153 at locations 1 and 2, respectively, compared to 12% and 37%, respectively, for CP 70-321. In the ratoon crop, no yield reduction occurred for LHo 83-153 at either location whereas CP 70-321 had a 9% reduction at location 2. Terbacil primarily affected yields by reducing stalk population, but the double rate of terbacil adversly affected both stalk population and stalk weight of CP 70-321. The sensitivity of CP 70-321 to terbacil was also observed by Richard (1989) who found that terbacil treatments in plant cane (silty loam soil, 0.6% organic matter) reduced cane yield of CP 70-321 by 29%, similar to the 32% reduction for CP 72-370. In the present study, variation in phytotoxicity at the two locations may have been related to soil differences--both soils were silty loams with 1.6% organic matter, but the clay content at location 1 was 16% compared to 14 % at location 2. This difference in clay content may have reduced the adsorptive capacity of the soil enough to cause the greater observed phytotoxicity. In any case, LHo 83-153 showed relatively good tolerance to terbacil on these soils.

HoCP 85-845 and LCP 85-384

In the first experiment on plant cane, a significant cultivar by herbicide treatment interaction was found for stalk population, stalk wt, cane yield, and sugar yield (Table 5). TRS was not greatly affected by herbicide treatment (data not presented). The reductions in cane yield by asulam and terbacil, respectively, were: HoCP 85-845 - 15% & 20%; LCP 85-384 - 16% & 59%; LCP 72-370 - 19% & 22%; and CP 74-383 - 10% & 0%. Terbacil had much more of a differential effect on cultivars than did asulam, causing a large yield reduction in CP 85-384 as compared to smaller but significant yield reductions in CP 72-370 and HoCP 85-845 and no reduction in CP 74-383. Results were very different in the 3-yr, second experiment since neither asulam or terbacil caused a significant decrease in cane yield of any cultivar, either in plant-cane or ratoon crops (Table 6). The greater phytotoxicity of terbacil in plant-cane of the first experiment as compared to the second was probably influenced by at least two factors, a higher rate of terbacil in spring (2.7 kg/ha vs 2.2 kg/ha) and the slightly lower soil organic matter (1.3% vs 1.4%) and clay (10% vs 12%).

LCP 86-454

Terbacil appeared to reduce yield more in CP 72-370 than in LCP 86-454 or CP 74-383 in the plant-cane crop of a 2-yr crop cycle, but the test for interaction was not significant (Table

7). Terbacil did reduce yield of cane (11%) and sugar (15%) as a mean of all cultivars in the plant-cane crop, but caused no significant reduction in the ratoon crop. These lower yields in plant cane were primarily caused by a reduction in stalk population rather than stalk weight or TRS (data not presented). Cane and sugar yields from the asulam treatment were lower but not significantly different from control.

In this study the newer and older cultivars varied in response to asulam and terbacil among experiments, but none of the newer cultivars were consistently less tolerant than CP 72-370, one of the most herbicide-sensitive cultivars. However, these herbicides usually caused some yield reduction in the newer cultivars, indicating that careful management practices will be required to minimize the possibility of injury as is now being done with CP 72-370. These practices include applying asulam early in the growing season (April or early May) to minimize the risk of injury, and avoiding or minimizing use of terbacil on very coarse-textured soils that are low in organic matter, particularly in the plant-cane crop. However, LHo 83-153 had relatively good tolerance to these herbicides, similar to that of CP 74-383, which is generally considered one of the most herbicide-tolerant cultivars, and should require less stringent management practices.

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Table 1. Comparison of newer cultivars LCP 82-89 and LHo 83-153 with CP 72-370 and CP 74-383 for tolerance to treatments with asulam and terbacil in the plant-cane crop.

	Cane yield					Sugar yield				
Herbicide treatment	LCP 82-89	LHo 83-153	CP 72-370	CP 74-383	Mean	LCP 82-89	LHo 83-153	CP 72-370	CP 74-383	Mean
	kg/ha (thousands)									
Control	79	89	74	85	82	11.0	12.0	9.6	10.4	10.8
Asulam[1]	68	80	74	82	76	9.1	11.3	9.6	9.6	9.9
Terbacil[2]	63	78	63	84	72	8.3	11.0	8.0	10.2	9.4
LSD(0.05)	--	--	--	--	5	--	--	--	--	1.2

[1] Asulam at 3.7 kg/ha applied during June in each crop.
[2] Terbacil applied at 1.8 kg/ha in fall after planting and 2.7 kg/ha the following spring.

Table 2. Comparison of newer cultivar LCP 82-89 with CP 72-370 and CP 74-383 for tolerance to treatments with asulam or terbacil applied during a 3-yr crop cycle.

Herbicide treatment by crop	Cane yield				Sugar yield			
	LCP 82-89	CP 72-370	CP 74-383	Mean	LCP 82-89	CP 72-370	CP 74-383	Mean
	---------------------------------- kg/ha (thousands)----------------------------------							
Plant cane:								
Control	66	71	75	71	7.2	9.2	8.8	8.4
Asulam[1]	62	62	72	65	6.9	7.5	7.4	7.3
Terbacil-A[2]	58	65	71	65	6.6	7.7	7.2	7.2
LSD (0.05)	--	--	--	4	--	--	--	0.6
1st-ratoon:								
Control	69	69	74	--	7.8	8.4	7.7	8.0
Asulam[1]	67	58	71	--	7.4	7.0	7.6	7.3
Terbacil-A[2]	67	65	72	--	7.4	7.7	7.2	7.4
Terbacil-B[3]	70	67	72	--	8.3	8.0	7.3	7.8
LSD (0.05)[4]	4	4	4	--	--	--	--	0.4
2nd-ratoon:								
Control	63	60	61	61	6.9	7.7	6.1	6.9
Asulam[1]	61	55	56	57	6.7	6.7	5.7	6.4
Terbacil-A[2]	61	62	64	62	7.1	8.0	6.6	7.2
Terbacil-B[3]	63	62	62	63	7.0	7.6	6.8	7.1
LSD (0.05)	--	--	--	3	--	--	--	0.4
Mean (3-yrs):								
Control	66	67	70	68	7.3	8.4	7.5	7.7
Asulam[1]	63	58	66	62	7.0	7.1	6.9	7.0
Terbacil-A[2]	62	64	69	65	7.0	7.8	7.0	7.3
Terbacil-B[3]	68	65	70	68	7.8	8.0	7.6	7.8
LSD (0.05)	--	--	--	2	--	--	--	0.4

[1] Asulam applied at 3.7 kg/ha during June in each crop.

[2] Terbacil-A applied at 1.8 kg/ha fall and 2.2 kg/ha spring in plant cane; 2.7 kg/ha spring in ratoons.

[3] Terbacil-B applied at 2.7 kg/ha spring only in the ratoon crops.

[4] Because of interaction, LSD values stated only for treatments within a cultivar.

Table 3. Comparison of newer cultivar LCP 82-89 with CP 70-321 for tolerance to asulam foliar treatments applied at monthly intervals in the first- and second-ratoon crops.

	Mean yield for 2-yr crop			
	Cane		Sugar	
Month treated[1]	LCP 82-89	CP 70-321	LCP 82-89	CP 70-321
	kg/ha (thousands)			
Control	63	63	9.2	8.9
April	63	68	9.2	9.5
May	62	63	9.0	8.9
June	57	63	8.3	9.2
LSD (0.05)[2]	4	4	0.7	0.7

[1] Asulam applied at approximately 30-day intervals in the first-ratoon crop and reapplied at these intervals in the second-ratoon crop.

[2] Because of interaction, LSD is stated for treatment means within a cultivar.

Table 4. Comparison of newer cultivar LHo 83-153 with CP 72-370 for tolerance to treatments with asulam or terbacil applied during a 3-yr crop cycle.

Herbicide treatment by crop	Cane yield			Sugar yield		
	LHo 83-153	CP 72-370	Mean	LHo 83-153	CP 72-370	Mean
	kg/ha (thousands)					
Plant cane:						
Control	76	68	72	6.9	7.8	7.3
Asulam[1]	75	63	69	6.8	7.5	7.2
Terbacil[2]	77	61	69	6.8	6.8	6.8
LSD (0.05)	--	--	NS	--	--	NS
1st-ratoon:						
Control	77	70	74	9.8	9.1	9.4
Asulam[1]	72	64	68	9.0	8.2	8.6
Terbacil[2]	76	62	69	9.4	8.1	8.8
LSD (0.05)	--	--	3	--	--	0.6
2nd-ratoon:						
Control	71	67	--	8.4	9.2	--
Asulam[1]	68	59	--	7.5	7.8	--
Terbacil[2]	76	62	--	9.2	8.4	--
LSD (0.05)[3]	5	5	--	0.9	0.9	--
Mean (3-years):						
Control	74	69	--	8.3	8.7	--
Asulam[1]	71	62	--	7.7	7.8	--
Terbacil[2]	76	62	--	8.5	7.7	--
LSD (0.05)[3]	3	3	--	0.6	0.6	--

[1] Asulam at 3.7 kg/ha applied annually in spring beginning in the plant-cane crop.

[2] Terbacil applied at 1.8 kg/ha after planting and at 2.7 kg/ha during each spring in plant cane and first- and second-ratoon crops.

[3] Because of an interaction, LSD values are stated only for treatment means within a cultivar.

Table 5. Comparison of newer cultivars HoCP 85-845 and LCP 85-384 with CP 72-370 and CP 74-383 for tolerance to treatments with asulam or terbacil in the plant-cane crop.

	Yield parameters							
Herbicide treatment	HoCP 85-845	LCP 85-384	CP 72-370	CP 74-383	HoCP 85-845	LCP 85-384	CP 72-370	CP 74-383
	Stalk population (thousands)				Cane yield (kg/ha in thousands)			
Control	74	107	68	63	94	117	86	81
Asulam[1]	69	95	63	58	80	98	70	73
Terbacil[2]	60	51	53	65	75	48	67	81
LSD (0.05)	14	14	14	14	17	17	17	17
	Stalk weight (g x 10)				Sugar/ha (kg/ha in thousands)			
Control	132	111	129	132	12.0	15.9	11.7	10.7
Asulam[1]	119	106	113	131	10.5	13.3	9.3	8.9
Terbacil[2]	128	95	129	128	9.8	6.2	9.0	10.2
LSD (0.05)	10	10	10	10	2.2	2.2	2.2	2.2

[1] Asulam at 3.7 kg/ha applied June.

[2] Terbacil applied at 1.8 kg/ha in fall after planting and 2.7 kg/ha the following spring.

Table 6. Comparison of newer cultivars HoCP 85-845 and LCP 85-384 with CP 72-370 and CP 74-383 for tolerance to treatments with asulam or terbacil applied during 3-yr crop cycle.

Herbicide treatment by crop	Cane yield					Sugar yield				
	HoCP 85-845	LCP 85-384	CP 72-370	CP 74-383	Mean	HoCP 85-845	LCP 85-834	CP 72-370	CP 74-383	Mean
	kg/ha (thousands)									
Plant cane:										
Control	66	68	59	62	64	8.6	9.3	8.0	7.8	8.4
Asulam[1]	63	70	54	58	61	8.0	9.6	6.9	6.8	7.8
Terbacil[2]	67	66	55	54	61	8.5	8.9	7.0	6.4	7.7
LSD (0.05)	--	--	--	--	NS	--	--	--	--	0.6
1st-ratoon:										
Control	64	79	64	56	66	8.1	9.4	8.4	5.5	7.9
Asulam[1]	65	84	59	53	65	8.0	9.8	7.4	5.0	7.6
Terbacil[2]	69	82	60	56	67	8.6	9.6	7.7	5.4	7.8
LSD (0.05)	--	--	--	--	NS	--	--	--	--	NS
2nd-ratoon:										
Control	72	84	68	66	72	9.1	10.6	8.9	7.4	9.0
Asulam[1]	73	85	63	63	71	9.3	11.1	8.1	6.6	8.8
Terbacil[2]	77	85	65	65	73	9.6	11.0	8.6	6.9	9.0
LSD (0.05)	--	--	--	--	NS	--	--	--	--	NS
Mean (3-yrs.)										
Control	67	77	64	61	67	8.6	9.8	8.4	6.9	8.4
Asulam[1]	67	79	59	58	66	8.4	10.2	7.5	6.2	8.1
Terbacil[2]	71	78	60	58	67	8.9	9.8	7.7	6.2	8.2
LSD (0.05)	--	--	--	--	NS	--	--	--	--	NS

[1] Asulam at 3.7 kg/ha applied annually in spring beginning in the plant cane crop.

[2] Terbacil applied at 1.8 kg/ha fall and 2.2 kg/ha spring plant cane; 2.7 kg/ha spring in ratoons.

Table 7. Comparison of new cultivar LCP 86-454 with cultivars CP 72-370 and CP 74-383 for tolerance to treatments with asulam or terbacil applied during a 2-yr crop.

Herbicide treatment by crop	Cane yield				Sugar yield			
	LCP 86-454	CP 72-370	CP 74-383	Mean	LCP 86-454	CP 72-370	CP 74-383	Mean
	kg/ha (thousands)							
Plant cane:								
Control	75	68	72	72	10.7	8.9	8.1	9.2
Asulam[1]	71	59	71	67	10.0	7.7	8.1	8.6
Terbacil[2]	67	47	69	61	9.0	5.6	7.2	7.3
LSD (0.05)	--	--	--	8	--	--	--	1.0
1st-ratoon:								
Control	72	67	78	72	10.5	9.1	10.1	9.9
Asulam[1]	71	63	66	67	10.0	8.6	9.0	9.2
Terbacil[2]	71	60	69	67	10.1	8.3	9.2	9.2
LSD (0.05)	--	--	--	NS	--	--	--	NS
Mean (2-yrs):								
Control	73	67	75	72	10.6	9.0	9.1	9.6
Asulam[1]	71	61	69	67	10.0	8.2	8.5	8.9
Terbacil[2]	69	53	69	64	9.6	6.9	8.2	8.2
LSD (0.05)	--	--	--	7	--	--	--	0.8

[1] Asulam at 3.7 kg/ha applied annually in spring beginning in the plant cane crop.

[2] Terbacil applied at 1.8 kg/ha fall and 2.2 kg/ha spring in plant cane; 2.7 kg/ha spring in the ratoon crop.

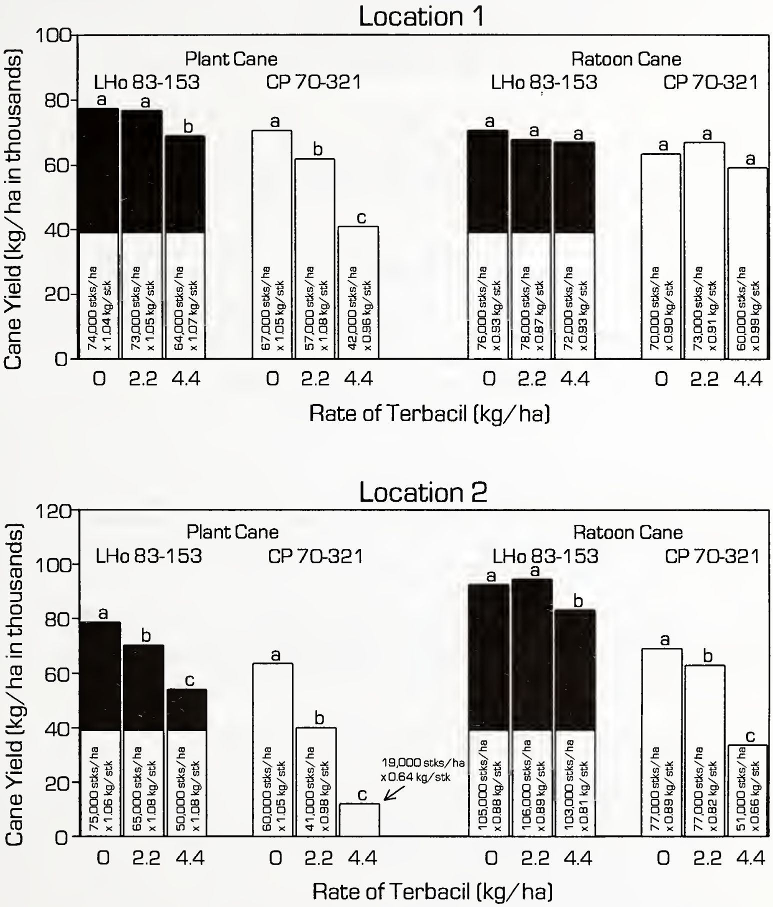

Figure 1. **Effect of terbacil rate and sugarcane crop on cane yield of cultivars LHo 83-153 and CP 70-321 at two locations. Components of cane yield--stalk population and stalk weight--are shown within the bars. Cane yields within a cultivar with the same letter at the top of the bar are not significantly different (*P*=0.05).**

POSSIBLE INTERACTION BETWEEN SUGARCANE RUST AND RATOON STUNTING DISEASE

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ABSTRACT

The severity of sugarcane rust, caused by *Puccinia melanocephala* has increased in specific fields on cultivars that were formerly classified as rust resistant. Since these cutivars are also susceptible to ratoon stunting disease that is caused by *Clavibacter xyli subsp. xyli* the possiblity of an interaction between the two diseases was evaluated. The effects on biomass production of sugarcane infected with ratoon stunting disease, or rust, and simultaneously with both their pathogens were determined in experiments conducted at Canal Point, Florida in 1993 and 1994. Biomass production of cultivars, CL 61-620 and CP 72-1210, was significantly reduced by *C. x. xyli* alone and by simultaneous infection with both pathogens. The isolate of *P. melanocephala* used in this study caused extensive pustule development on CP 72-1210 but little or no pustule development on CL 61-620. *P. melanocephala* significantly reduced biomass production of cultivar CP 72-1210 but not CL 61-620. A significant statistical-interaction for biomass was not detected between the two diseases. A significant statistical-interaction was detected using estimates of the top visible dewlap leaf area infected and rust severity ratings for CP 72-1210 in analysis of combined experiments from 1993 and 1994. Its biological importance is questionable because of small differences in rust symptoms and inconsistencies between experiments. Therefore, no evidence was found of a meaningful statistical interaction regarding the effects of sugarcane rust and ratoon stunting disease.

INTRODUCTION

Common rust, caused by *Puccinia melanocephala* Syd. & P. Syd., and ratoon stunting disease (RSD), caused by *Clavibacter xyli* subsp. *xyli* Davis et al. (1984), are two important diseases of sugarcane (interspecfic hybrids of *Saccharum* spp.) in Florida. Both rust (Comstock et al., 1992a; 1992b) and RSD (Dean and Davis, 1989; Irey, 1986) cause yield losses in Florida. The RSD pathogen is found in the xylem cells of sugarcane (Gillaspie and Teakle, 1989). Rust causes localized pustules that erupt on the adaxial leaf surface (Ryan and Egan, 1989). RSD stalk infection is nearly 100% in commercial sugarcane fields of cultivars CL 61-620 and CP 72-1210 in Florida that had been planted with seedcane with no heat therapy and sanitation practices (Comstock et al., 1993; 1995). The incidence of rust infection is greatest during March through May and varies by cultivar, field location, and crop year. During this period, some commercial fields of CL 61-620 and CP 72-1210 develop moderate to severe rust symptoms. Consequently, *C. x. xyli* and *P. melanocephala* can be simultaneously infecting susceptible commercial plantings.

RSD yield loss estimates were determined in field trials (Dean and Davis, 1989; Irey, 1986). Dean and Davis (1989) showed a 5.5 to 6.0% yield loss for cultivars CP 65-357, CP 70-1133, and CP 72-1210 averaged over a three year cropping cycle in four locations. Irey (1986) detected a 5.9% lower yield of tons of sugar per hectare in the RSD infected plots late in the crop involving six cultivars. Dean (1983) reported losses of -6.8 to 23.2% due to RSD using single stools (plants) as an experimental unit. Rust-induced yield losses ranging from 0 to 40.9% were reported also using single stools as an experimental unit (Comstock et al., 1992a; 1992b). These experiments were conducted in a photoperiod house to control rust infection on the check plants.

The potential for a statistically significant rust by RSD interaction has not been studied. Field observations indicate that such an interaction may exist since the degree of yield loss, particularly in CP 72-1210, cannot be explained by expected losses due to either disease alone. There are numerous studies of the combined effects of two pathogens infecting a single host. These effects may be antagonistic (Bockus, 1994; Erasmus and von Wechmar, 1983), additive (Damsteegt and Bonde, 1993; Simkin, and Wheeler, 1974), or synergistic (Ross, 1968). Rust diseases of cereals were suppressed on plants infected with viral pathogens (Bockus, 1994; Erasmus and von Wechmar, 1983). The purpose of this research was to determine if there was a statistically significant interaction between *P. melanocephala* and *C. x. xyli* with respect to yield loss and severity of rust symptoms in sugarcane.

MATERIALS AND METHODS

Experimental Design

The interaction between *C. x. xyli* and *P. melanocephala* was evaluated by measuring biomass and estimating rust severity on two commercial cultivars, CP 72-1210 and CL 61-620 using two diseases (rust and RSD) each with two disease states (uninoculated controls and inoculated). The experimental design was a 2×2×2 factorial replicated 24 times and was conducted over two years. A single plant served as the experimental unit.

Two plant crops were evaluated, the first in 1993 and the second in 1994. Single-bud vegetative seedpieces were propagated in flats during December 1992 and December 1993. In the 1993 experiment, plants were transplanted to plastic pots (27 cm diameter × 24 cm deep) during February 1993. Plants were grown on carts that were moved into a photoperiod house at night (25°C) and when rain was imminent. This effectively prevented leaf moisture conditions that would allow transient rust infection. Plants were brought out of the photoperiod house each morning. Plants were maintained on the carts until 14 June 1993, and then, transplanted to the field. In the 1994 experiment, plants were transplanted to pots in March 1994 and placed on the photoperiod carts until 21 June 1994 when they were transplanted to the field. Fresh weights of field plants were determined on whole plants harvested above soil line on 14 February 1994 and 27 January 1995. All other aspects of the experiments were similar.

Inoculation of Plants

Single-bud seedpieces were obtained from a heat-treated seed source known to be free of RSD. Cultivars, CP 72-1210 and CL 61-620, were selected because they are known to be susceptible to RSD. CP 72-1210 was susceptible to the isolate of rust used in this experiment. Seedpieces were inoculated with RSD by immersing them in sugarcane juice expressed from *C. x. xyli*-infected stalks of CP 53-1, a cultivar known to maintain high populations of *C. x. xyli*. The rust-treated plants were inoculated biweekly by covering the plants with a plastic bag and spraying the leaves with *P. melanocephala* spore suspensions ($8\text{-}10 \times 10^4$ urediniospores/ml using 0.5 ml per plant). Rust inoculations began on 26 March and ended 4 June in the 1993 experiment, and were initiated on 15 April and ended 4 June in the 1994 experiment.

Rust Severity Evaluation

Rust severity ratings were determined weekly from 29 April to 10 June in both years. The percent area of the top visible dewlap leaf (TVD) with lesions was estimated using a severity rating scale from 1 to 9 (Comstock and Ferreira, 1986) with 1 having no rust symptoms and 9 the most severe rust symptoms. Weekly mean severity were used in data analysis.

RSD Detection

The RSD status of plants was verified by the modified tissue blot immunoassay (Davis et al., 1994) since there are no external symptoms. These data were used only to certify the presence or absence of RSD, not the degree of infection.

Sugarcane Biomass Measurements

Fresh weight of the entire plant above ground (including stalks and leaves) was determined for each plant at harvest.

Data Analysis

Analyses of variance were conducted using PROC GLM in SAS version 6.04 (SAS Institute, Inc., Cary, NC 27513) on whole plant biomass, rust severity ratings and percent TVD leaf area infected following a square-root transformation. Uninoculated plants that tested positive for RSD were discarded from the analysis. Cross infection by rust was extremely low and all data were included in the analysis.

RESULTS

Above-ground biomass, percent TVD infected leaf area and rust ratings were significantly different between years and between cultivars (Table 1). Interaction of cultivar × rust was detected using both estimates of rust severity but not for biomass determinations. No cultivar × RSD interaction was detected using any parameter.

Plant biomass for treatments inoculated either with *P. melanocephala*, *C. x. xyli* singly or with both pathogens was significantly less than that of uninoculated plants across years for CP 72-1210 (Table 2). Biomass did not significantly differ between the uninoculated and rust-inoculated plants in CL 61-620. CL 61-620 plants inoculated with *C. x. xyli* weighed significantly less than plants not inoculated with *C. x. xyli,* regardless of rust severity over both years. No differences in biomass were detected between treatments on CL 61-620 in 1994. Tissue blot immunoassay revealed that eight of 24 replicates of the uninoculated treatment and 12 of 24 of the rust treatments were infected with *C. x. xyli* in 1994. Infection was probably the result of an improper heat-treatment of the original seedcane. This reduced the number of replicates and the sensitivity of the statistical analysis.

Rust severity differed on the two cultivars based on rust ratings (Table 3) and percent TVD leaf area with pustules (Table 4); CP 72-1210 was susceptible while CL 61-620 was resistant to the *P. melanocephala* isolate used. The 1993 and 1994 experiments gave inconsistent results with respect to rust development on CP 72-1210 between single and dual pathogen inoculations. The percent TVD leaf area with pustules on CP 72-1210 was 41.86 for dual pathogen versus 39.11 for *P. melanocephala* inoculations only. The similarity of these infected leaf areas although statistically different, make the biological importance questionable. Plants inoculated only with *P. melanocephala*, had more rust symptoms than dual pathogen inoculated plants in 1994. The same holds true with rust severity ratings, but no differences were observed in 1993. The greatest level of rust that developed on CL 61-620 in either year was 3.17%. This supports the claim that CL 61-620 was resistant to the isolate used in the experiment. Ratings indicate that rust development on plants not inoculated with rust was minor (<1% TVD area with pustules) and therefore of no significance.

DISCUSSION

RSD and rust reduced sugarcane biomass production. RSD caused an 11.8 and 10.3% yield reduction in CL 61-620 and CP 72-1210, respectively, for the two years. Rust caused a 15% biomass reduction in CP 72-1210. No biomass reduction was observed in CL 61-620 due to rust. The yield reductions were comparable to those reported for RSD (Dean and Davis, 1989; Irey, 1986) in CP 72-1210 and for rust (Comstock et al., 1992a; 1992b) in other cultivars. These yield losses verify the importance of these two diseases in the Florida sugarcane industry.

Sugarcane yield reductions due to diseases are difficult to estimate because of the difficulty in maintaining healthy control plots. Healthy plots easily become infected with aerially transmitted pathogens such as rust. The inability to obtain adequate disease levels in field experiments also hampers accurate yield-loss determinations. The photoperiod house at Canal Point has been used in these experiments and previous studies (Comstock et al., 1992a; 1992b) to prevent dew formation. This effectively prevented rust infection on non-inoculated plants. Single-plant plots with high numbers of replicates proved suitable for obtaining yield data that can determine significance between small differences in treatments.

RSD × rust interaction was detected using rust severity estimates but not by biomass determination. This difference in detecting interaction using the two methods may reflect the greater sensitivity in determining rust severity estimates than biomass determinations. Although the rust × RSD term in the ANOVA was significant for both severity parameters in the combined analysis, there were inconsistencies between 1993 and 1994 experiments, with respect to rust severity on CP 72-1210 plants inoculated with *P. melanocephala* alone and with the dual pathogen inoculation. Rust severity was less on dual pathogen inoculated plants of CP 72-1210 in the 1994 experiment but not in the 1993 experiment. These inconsistencies plus the lack of detecting an interaction using biomass determinations, suggest that the statistical RSD × rust interaction found in the rust severity measurements may not be important. The effect of each disease on crop yield is additive and not synergistic as indicated by the lack of significance of the rust × RSD.

Rust pathogens were suppressed in virus infected plants with stem rust of wheat (Erasmus and von Wechmar, 1983), and crown rust of ryegrass (Latch and Potter, 1977). Rust tends to be more severe on vigorously growing plantings of susceptible cultivars. This may explain the slightly reduced rust severity observed in this experiment in the dual pathogen inoculations.

Sugarcane rust has increased on CP 72-1210 during the last 10-15 years. Since the incidence of RSD is nearly 100% in fields of CL 61-620 and CP 72-1210 planted with seedcane without prior hot-water-treatment, the increased rust severity was thought to be due to the interaction with RSD. Based on our results, a pathogenic race change in sugarcane rust is now the more likely explanation for the increased rust development on CP 72-1210 in recent years.

Since the differences in rust severity estimates between *P. melanocephala* and dual pathogen inoculations are slight, cultivar ratings in the development program would be minimally influenced. Consequently, screening programs currently being used to evaluate rust and RSD resistance do not have to be altered.

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Table 1. Analyses of variance[w] of biomass, rust severity ratings and percent top visible dewlap (TVD) leaf area infected with rust for sugarcane cultivars CL 61-620 and CP 72-1210 in four disease states: no disease, ratoon stunting disease (RSD), rust, and RSD+rust.

Source	df	Biomass[x]		Rust ratings[y]		% TVD leaf inf.[z]	
		Mean Square	F	Mean Square	F	Mean Square	F
Year	1	540.58	10.44**	0.52	3.08*	7.47	20.75*
Error$_a$							
Rep(yr)	46	51.79		0.17		0.36	
Cv.	1	425.67	30.10**	91.60	723.10**	444.50	1918.34**
RSD	1	204.66	14.47**	1.02	8.03**	3.71	16.00**
Cv×RSD	1	22.36	1.58	0.13	1.01	0.09	0.39
Rust	1	103.86	7.34**	814.51	6429.70**	1133.12	4890.28**
Cv×rust	1	33.32	2.36	88.43	698.12**	428.32	1848.54**
Rust×RSD	1	0.54	0.04	1.01	7.98**	3.65	15.76**
Error$_b$	302	14.14		0.13		0.23	

[w] Partial analysis of variance presented. Other interactions were not significant.

[x] Fresh weight biomass (kg) was determined on all above ground stalks and leaves of plants at harvest.

[y] Rust ratings were estimated on a 1 to 9 scale (2). The ratings ranged from plants with a 1 rating with no visible rust symptoms to a 9 rating with the most severe rust symptoms, numerous pustules on the upper leaves and extensive necrosis of the lower leaves.

[z] The percent top visible dewlap (TVD) leaf area infected was visually estimated weekly. Analyses were performed on square root transformed data.

* *P=0.10*

** P=*0.01*

Table 2. Mean biomass production (kg fresh weight[a]) for sugarcane cultivars CL 61-620 and CP 72-1210 in four disease states: no disease, ratoon stunting disease (RSD), rust, and RSD+rust.

Disease State		Combined expts.		1993 experiment		1994 experiment	
RSD	Rust	CL 61-620	CP 72-1210	CL 61-620	CP 72-1210	CL 61-620	CP 72-1210
–	–	18.02a	15.93a	19.84a	16.96a	15.30a	14.85a
+	–	15.90b	14.28b	17.13bc	15.32ab	14.67a	13.25b
–	+	18.00a	13.60b	19.12ab	14.59b	15.76a	12.60b
+	+	14.97b	13.18b	15.54c	14.33b	14.40a	12.05b
LSD(0.05)		1.67	1.39	2.54	2.35	1.93	1.56
				P > F			
RSD		<0.01	0.04	<0.01	0.25	0.23	0.05
Rust		0.44	<0.01	0.21	0.05	0.80	<0.01
RSD×Rust		0.48	0.22	0.63	0.42	0.54	0.32

[a] Fresh weight biomass (kg) was determined on all above ground stalks and leaves of plants at harvest. Letters in columns, when different, indicate significant differences using Fisher's least significant difference (LSD) $P \leq 0.05$.

Table 3. Rust severity ratings[a] for sugarcane cultivars CL 61-620 and CP 72-1210 in four disease states: no disease, ratoon stunting disease (RSD), rust, and RSD+rust.

Disease State		Combined expts.		1993 experiment		1994 experiment	
RSD	Rust	CL 61-620	CP 72-1210	CL 61-620	CP 72-1210	CL 61-620	CP 72-1210
–	–	1.00c	1.03c	1.01c	1.03b	1.00b	1.03c
+	–	1.01c	1.02c	1.00c	1.04b	1.01b	1.00c
–	+	3.13a	5.24a	3.17a	5.12a	3.06a	5.35a
+	+	2.99b	4.95b	3.00b	5.30a	2.97a	4.60b
LSD(0.05)		0.10	0.19	0.14	0.18	0.17	0.29
				P > F			
RSD		0.09	0.02	0.07	0.14	0.48	<0.01
Rust		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RSD×Rust		0.09	0.02	0.10	0.21	0.41	<0.01

[a] Rust ratings were estimated on a 1 to 9 scale (2). Where: 1 = no visible rust symptoms; 3 = a few sporulating pustules; 5 = a moderate number of sporulating pustules on upper leaves with numerous pustules on lower leaves; 7 = numerous pustules on upper leaves and necrosis on lower leaves; 9 = numerous pustules and moderate necrosis on the upper leaves and extensive necrosis of the lower leaves. Letters in columns, when different, indicate significant differences using Fisher's Least Significant Difference (LSD) $P \leq 0.05$.

Table 4. Percent top visible dewlap (TVD) leaf area infected[a] with rust for sugarcane cultivars CL 61-620 and CP 72-1210 in four disease states: no disease, ratoon stunting disease (RSD), rust, and RSD+rust.

Disease State		Combined expts.		1993 experiment		1994 experiment	
RSD	Rust	CL 61-620	CP 72-1210	CL 61-620	CP 72-1210	CL 61-620	CP 72-1210
–	–	0.01c	0.03c	0.00c	0.04c	0.02c	0.01c
+	–	0.00c	0.03c	0.00c	0.07c	0.00c	0.00c
–	+	2.80a	38.61a	3.12a	39.11b	2.15a	38.11a
+	+	1.59b	33.47b	1.85b	41.86a	1.30b	24.72b
LSD(0.05)		0.10	0.28	0.14	0.22	0.11	0.43
				$P > F$			
RSD		<0.01	<0.01	<0.01	0.14	<0.01	<0.01
Rust		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
RSD×Rust		<0.01	<0.01	<0.01	0.14	<0.01	<0.01

[a] The % top visible dewlap (TVD) leaf area infected was visually estimated weekly. Original data presented, means were determined and analyses were performed on square root transformed data. Letters in columns, when different, indicate significant differences using Fisher's least significant difference (LSD) $P \leq 0.05$.

SURFACE RUNOFF CONTAMINATION AS AFFECTED BY SUGARCANE MANAGEMENT PRACTICES[1]

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ABSTRACT

An experiment was conducted at St. Gabriel, Louisiana, to quantify the movement of soil, plant nutrients, and herbicides in surface runoff from sugarcane plots under three different management practices. These data were needed to determine the effectiveness of best management practices (BMPs) on reducing non-point source pollutants from sugarcane fields. Experimental plots were located on a Commerce silt loam (Aeric Fluvaquent, fine-silty, mixed, non-acid, thermic) soil. Three treatments (high, standard, and low management practices) replicated twice were imposed on the plots. The high management treatment consisted of 180, 80, and 120 lbs/ac of N, K_2O, and P_2O_5, respectively, with herbicides (atrazine and metribuzin) applied full broadcast. The standard management treatment consisted of 120, 40, and 80 lbs/ac of N, K_2O, and P_2O_5, respectively with herbicides applied in a 36-inch band over the row. This is the cultural practice recommended by the Louisiana Cooperative Extension Service. The low management treatment consisted of 60, 0, and 0 lbs/ac of N, K_2O, and P_2O_5, respectively with herbicides applied in a 24-inch band over the row. Average soil losses differed only slightly among the three treatments with 7.74, 7.72, and 8.04 tons/ac measured from high, standard, and low management practices, respectively. Total nitrogen loss from the high management practice was 20.8 lbs/ac which was 109% more than the 9.9 lbs/ac measured from the low management treatment. Total phosphorous losses were about the same among treatments with 13.3, 12.3, and 11.3 lbs/ac measured from the high, standard, and low management practices, respectively. Total potassium losses were similar for the high (89.9 lbs/ac) and standard (93.1 lbs/ac) management treatments. These losses were 29% higher than 70.8 lbs/ac measured from the low management treatment. Herbicide losses also varied among treatments. Atrazine losses were 2.24, 0.82, and 0.48 oz/ac from the high, standard and low management treatments, respectively. Sencor losses were 1.12, 0.65, and 0.18 oz/ac from the high, standard and low management treatments, respectively.

INTRODUCTION

Contamination of agricultural chemicals in surface and ground water is a national concern. A primary purpose of the USEPA Clean Water Act (Section 319) and the Coastal Zone Management Act (Section 6217) is to evaluate, demonstrate, and implement best management practices (BMPs) to improve water quality in watersheds nationwide (Louisiana Department of

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Environmental Quality, 1990). Because sediments, agricultural chemicals and plant nutrients are potential contributors to nonpoint source pollution, it is essential to quantify inputs and effectiveness of BMPs that improve water quality.

Little has been published in Louisiana regarding contamination of surface and ground waters by fertilizers, herbicides, and insecticides used in sugarcane production. The Louisiana Department of Environmental Quality (1990) indicated that most water bodies are contaminated to some degree. The purpose of this study was to quantify the fate of applied chemicals in the soils in southern Louisiana and to evaluate the effectiveness of three different sugarcane management practices on the movement of soil, nitrogen, phosphorus, potassium, atrazine, and metribizin in surface water runoff.

MATERIALS AND METHODS

This study was initiated in 1992 and consisted of three treatments, two replications, and three growing seasons (plant cane, first ratoon, and second ratoon). The site chosen was at the Louisiana Agricultural Experiment Station's St. Gabriel Research Station located 12 miles south of Baton Rouge.

Six leveed plots, 0.6 acres in size (nine rows spaced 6-ft apart and 460 feet long), were located on a Commerce silt loam soil (Aeric Fluvaquent, fine-silty, mixed, non-acid, thermic) (Camp, 1976 and Rogers et al., 1985) and planted in CP 70-321 sugarcane cultivar on 15 Sept. 1992. The plots had a 0.1% slope. Three treatments (high, standard, and low management practices) replicated twice were imposed on the plots. One object of the project was to determine if varying the agricultural chemical inputs to the sugarcane biological system would vary the amount of surface water contamination flowing from the field. This was accomplished by choosing the amounts of chemicals to be applied to the plots to be the same, above, and below that recommended by the Louisiana Cooperative Extension Service for sugarcane in Louisiana. The high management treatment consisted of 180, 80, and 120 lbs/ac of N, K_2O, and P_2O_5, respectively. Atrazine and metribuzin were applied broadcast (100% coverage) at rates of 28.6 and 31.5 oz/ac, respectively. The standard management treatment consisted of 120, 40, and 80 lbs/ac of N, K_2O, and P_2O_5, respectively. Atrazine and metribuzin were applied in a 36-inch band over the row (50% coverage) at rates of 11.4 and 15.7 oz/ac, respectively. This is the cultural practice recommended by the Louisiana Cooperative Extension Service. The low management treatment consisted of 60, 0, and 0 lbs/ac of N, K_2O, and P_2O_5, respectively. Atrazine and metribuzin were applied in a 24-inch band over the row (33% coverage) at rates of 10.0 and 10.6 oz/ac, respectively.

An electric sump pump was installed in a sump on the low side of each plot. Runoff was measured with a Rockwell water meter and sampled with an ISCO automatic water sampler. Sample collection was triggered automatically when runoff was detected by a sensor. Runoff samples were analyzed by the LSU Agricultural Chemistry Department for total solids, nitrogen, phosphorous, potassium, atrazine, and metribuzin. Nitrogen was determined by an automated colorimetric procedure developed by Wall and Gehrke (1979). Phosphorus and potassium were determined by method 200.2 developed by Martin, et al. (1991). Atrazine and metribuzin were measured using a Hewlett-Packard 5890A Series II gas chromatograph with He as the carrier gas and ^{63}Ni as the electron capture detector (Gaston and Lock, 1995). These analyses determined the totals in both solutions and solids. Using the amount of surface runoff and concentrations, total loadings were calculated. The data from the 3 years were composited into average annual values. The paired t-test described by Steel and Torrie (1960) was used to determined significance between the average annual values.

RESULTS AND DISCUSSION

Sugarcane was harvested on November 23, 1993; November 9, 1994; and October 18, 1995. The annual average cane yields were 28.80, 28.93, and 27.65 tons/ac (Table 1) for the high, standard, and low treatments, respectively. The annual average sugar yields were 5785, 5704, and 5424 lbs/ac for the high, standard, and low treatments, respectively. Although there were no significant differences *($P \leq 0.05$)* for cane yields or sugar yields among the treatments, the high and standard treatments produced 300 lbs/ac more sugar than did the low treatment. The additional 60, 40, and 40 lbs/ac of N, K_2O, and P_2O_5, respectively, of fertilizer used in the high treatment over the standard treatment did not significantly increase the growth of the cane or sugar yields. The reduction of 60, 40, and 80 lbs/ac of N, K_2O, and P_2O_5, respectively, used in the low treatment with respect to the standard treatment reduced the growth of cane and sugar yields, but not significantly.

For 1993, 1994, and 1995, the average annual rainfall was 57.06 inches (Table 2), which was close to the normal of 56.87 inches. The average annual surface runoff was 27.14, 26.87, and 27.05 inches for the high, standard, and low treatments, respectively (Table 3). There were no significant differences among the treatments ($P \leq 0.05$). The highest monthly runoff was in March (6.48 in) and the two lowest were in August (0.10 in) and September (0.08 in). As a consequence of similar cane growth on all plots, there was no significant difference in surface runoff.

The average annual soil losses were 7.74, 7.72, and 8.04 tons/ac (Table 4) for the high, standard, and low treatments, respectively. There were no significant differences among the treatments ($P \leq 0.05$). The highest monthly soil loss was in March (1.50 tons/ac) and the lowest in August and September. As a consequence of similar cane growth on all plots, there was no significant difference in soil loss.

The average annual nitrogen losses were 20.82, 16.10, and 9.94 lbs/ac (Table 5) for the high, standard, and low treatments, respectively. There were no significant differences between the high and standard treatments ($P \leq 0.05$). However, the low treatment was significantly different from both the high and standard treatments ($P \leq 0.05$). Reducing the amount of nitrogen applied to the low amount (60 lbs/ac) significantly reduced the amount of nitrogen lost in the surface runoff. The highest monthly nitrogen loss was in June (5.77 lbs/ac) and the lowest was in August and September. The large loss in June was caused by large amounts of rain soon after the nitrogen was applied.

The average annual phosphorus losses were 13.30, 12.30, and 11.30 lbs/ac (Table 6) for the high, standard, and low treatments, respectively. There were no significant differences among the treatments ($P \leq 0.05$). The highest monthly phosphorus loss was in May (2.06 lbs/ac) and the lowest was in September (0.03 lbs/ac).

The average annual potassium losses were 89.90, 93.13, and 70.82 lbs/ac (Table 7) for the high, standard, and low treatments, respectively. There was no significant difference between the high and standard treatments ($P \leq 0.05$). However, the low treatment was significantly different from both the high and standard treatments ($P \leq 0.05$). Reducing the amount of potassium applied to zero lbs/ac significantly reduced the amount of potassium lost in the surface runoff. The highest monthly potassium loss was in January (15.83 lbs/ac) and the lowest was in August (0.19 lbs/ac). Nitrogen and potassium losses from the high management treatment did not differ significantly from the standard management treatment but the losses of these nutrients from the low management treatment were significantly less than those from both the high and standard management treatments.

Atrazine was applied to the plots on Jan. 1993, 6 Jan. 1994, and 20 Dec. 1994. Results were not collected from the January 1993 application because the instrumentation had not been installed. The average annual atrazine losses were 2.24, 0.82, and 0.48 oz/ac (Table 8) for the high, standard, and low treatments, respectively. The three treatments were significantly different ($P \leq 0.05$). Reducing the amount of atrazine applied and banding the herbicide on the top of the cane row significantly reduced the amount lost in the surface runoff. The largest monthly atrazine loss was in January because this was shortly after application and the soils were saturated with winter rains. Grass grew on the sides of the rows for the 36 and 24 inches band applications. The weed control was satisfactory for these treatments because the grass growing on the sides of the rows was removed by cultivation in the spring and grass did not grow among the cane plants. The atrazine losses from the broadcast method used in the high treatment were 173% greater than for the 36 inches band used in the standard treatment. The herbicide falling between the rows from the broadcast method washed off with the surface runoff causing the large herbicide loss from that method. Applying atrazine in 24 inches bands (low management treatment) reduced atrazine losses by 42% compared to the 36 inches bands (standard management practice).

Metribuzin was applied to the plots in March of 1993, 1994 and 1995. Results were not collected from the March 1993 application because the instrumentation had not been installed. The average annual metribuzin losses were 1.12, 0.65, and 0.18 oz/ac (Table 9) for the high, standard, and low treatments, respectively. The three treatments were significantly different ($P \leq 0.05$). Reducing the amount of metribuzin applied and banding on the top of the cane row significantly reduced the amount lost in the surface runoff. The metribuzin losses from the broadcast method (high management treatment) were 72% greater than for the 36 inches bands (standard management treatment). The 24 inches bands used in the low management treatment reduced metribuzin losses by 72% from the 36 inches bands.

CONCLUSIONS

Based on these results, the standard management treatment provided the best yields with optimum fertilizer utilization and the lowest pesticide amounts needed. The standard fertilizer application (120-40-80 lbs/ac of N-P_2O_5-K_2O) used in this study reflects the recommended cultural practice for sugarcane in southern Louisiana.

We recommend the 24 inches banding method of applying herbicides as the BMP. This method keeps the grasses and weeds out of the cane row. The grass growing on the sides of the rows during the winter is removed by physical cultivation in the spring. The BMP reduces herbicide loss by 78% from the broadcast method.

A small reduction in applied chemicals did not affect surface water contamination. A large reduction in applied chemicals reduced surface water contamination.

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Table 1. Annual Sugarcane Yields

Treatment	Year	Stalks per acre	Cane yield	Sugar yield
		#	tons per acre	lbs per acre
High	1993	30,750	26.90	5,218
High	1994	24,500	31.35	6,810
High	1995	29,500	28.15	5,328
Mean		28,250*	28.80	5,785
Standard	1993	30,350	26.95	4,838
Standard	1994	26,500	31.55	6,888
Standard	1995	25,950	28.30	5,386
Mean		27,600	28.93	5,704
Low	1993	26,500	27.15	5,041
Low	1994	25,900	29.50	6,470
Low	1995	27,900	26.30	4,762
Mean		26,767	27.65	5,424

*Mean yields for high, standard, and low treatments were not significantly different at $P \leq 0.05$ for stalks per acre, cane yield, or sugar yield.

Table 2. Annual Rainfall

Year	Rainfall
1993	52.48
1994	56.47
1995	62.23
Mean	57.06

Historic average annual rainfall = 56.87 inches.

Table 3. Average monthly rainfall and surface runoff

		-------------Surface Runoff	-------------	
Month	Rainfall	High	Standard	Low
	inches	------------------	inches	------------------
January	5.59	3.34	3.18	3.30
February	2.98	2.04	1.80	1.93
March	7.59	6.70	6.41	6.34
April	5.84	2.38	2.38	2.68
May	5.90	2.33	2.51	2.32
June	6.33	3.17	3.14	3.23
July	3.48	1.07	1.11	1.11
August	2.68	0.10	0.10	0.09
September	2.22	0.08	0.10	0.08
October	6.29	2.59	2.59	2.59
November	3.87	1.60	1.68	1.76
December	4.29	1.74	1.87	1.62
Total	57.06	27.14*	26.87	27.05

Average Annual Rainfall = 56.87 inches.

*Total runoff values were not significantly different at $P \leq 0.05$

Table 4. Average monthly soil loss.

Month	Soil Loss High	Soil Loss Standard	Soil Loss Low
	tons per acre		
January	1.06	0.58	1.08
February	0.51	0.56	0.33
March	1.50	1.42	1.49
April	0.99	0.95	1.04
May	1.22	1.43	1.27
June	0.94	1.17	0.91
July	0.29	0.23	0.23
August	0.01	0.02	0.02
September	0.01	0.01	0.01
October	0.55	0.58	0.48
November	0.25	0.30	0.42
December	0.40	0.47	0.78
Total	7.74*	7.72	8.04

*Soil losses among high, standard, and low treatments were not significantly different at $P \leq 0.05$.

Table 5. Average monthly nitrogen loss.

Month	Nitrogen loss		
	High	Standard	Low
	lbs per acre		
January	1.80	1.84	1.34
February	0.46	0.33	0.18
March	1.27	0.72	0.71
April	1.37	1.50	1.25
May	3.74	4.57	1.66
June	5.77	3.07	1.53
July	1.86	0.57	0.24
August	0.05	0.06	0.04
September	0.04	0.06	0.02
October	3.03	1.98	1.64
November	0.73	0.58	0.64
December	0.69	0.84	0.69
Total	20.82A*	16.10A	9.94B

*Nitrogen losses followed by different letters are significantly different at $P \leq 0.05$ level.

Table 6. Average monthly phosphorus loss

Month	High	Standard	Low
	-----Phosphorus loss-----		
	-----lbs per acre-----		
January	1.96	1.40	1.78
February	0.72	0.83	0.48
March	1.77	1.75	1.47
April	1.58	0.99	1.01
May	2.19	2.49	1.50
June	0.87	0.87	0.70
July	0.07	0.04	0.07
August	0.05	0.07	0.03
September	0.03	0.04	0.01
October	0.79	0.52	0.49
November	1.09	1.10	0.94
December	2.18	2.21	2.82
Total	13.30*	12.30	11.30

*Phosphorus losses among high, standard, and low treatments were not significantly different at $P \leq 0.05$.

Table 7. Average monthly potassium loss

Month	High	Standard	Low
	lbs per acre		
January	15.83	12.78	12.18
February	5.92	5.89	3.16
March	13.40	13.00	9.30
April	9.41	8.30	8.89
May	11.45	13.25	9.52
June	7.48	7.95	7.37
July	1.71	2.44	0.95
August	0.16	0.26	0.15
September	0.20	0.44	0.18
October	5.42	5.19	4.10
November	10.07	12.67	6.20
December	8.85	10.96	8.82
Total	89.90A*	93.13A	70.82B

*Potassium losses followed by different letters are significantly different at $p \leq 0.05$ level.

Table 8. Annual atrazine loss.

Year	Atrazine loss		
	High	Standard	Low
	ounces per acre		
1994	3.56	1.32	0.76
1995	0.92	0.33	0.20
Mean	2.24A*	0.82B	0.48C

*Atrazine losses followed by different letters are significantly different at $P \leq 0.05$ level.

Table 9. Annual metribuzin loss.

Year	Metribuzin Loss		
	High	Standard	Low
	ounces per acre		
1994	0.09	0.05	0.03
1995	2.15	1.24	0.33
Mean	1.12A*	0.65B	0.18C

*Metribuzin losses followed by different letters are significantly different at $P \leq 0.05$ level.

RATOON STUNTING DISEASE IN FLORIDA SUGARCANE FIELDS: RELATIONSHIP BETWEEN DISEASE INCIDENCE AND CULTIVAR RESISTANCE

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ABSTRACT

The incidence of ratoon stunting disease (RSD), caused by *Clavibacter xyli subsp. xyli* Davis et al. (1984), varied in commercial sugarcane fields that lacked a RSD control program. RSD incidences in sugarcane fields varied by cultivar resistance as determined by the number of colonized vascular bundles (CVB). Resistant cultivars had a low incidence of RSD and also had a low number of CVB. Susceptible cultivars, CP 70-1133 and CP 72-1210, had an incidence of greater than 90% stalks infected and averaged more than 6 CVB per 1 cm diameter standard stalk sample. In contrast, resistant cultivars, CL 73-239 and CP 72-2086, had 2.7 and 1.4% stalks infected in the fields surveyed and averaged less than 0.5 CVB per stalk. Since these cultivars have been grown for several years without a RSD control program, resistance appears to have limited the spread of the disease.

INTRODUCTION

Ratoon stunting disease is a major disease of sugarcane worldwide (Gillaspie and Teakle, 1989). Losses up to 50% have been reported on highly susceptible cultivars (Gillaspie and Teakle, 1989). A 5% yield loss due to RSD was detected in Florida (Dean and Davis, 1989; Irey, 1986). These losses reported in Florida varied by cultivar. In addition to the economic losses due to reduced yields, RSD control programs such as hot-water-treatment of seedcane are an additional expense.

RSD has no external symptoms other than a reduction of plant growth. Internal symptoms are of two types: In young plants there is a general pink color near the apical meristem. In mature stalks there is a reddish discoloration of individual vascular bundles at the older nodes at the base of the plant. The vascular bundle discoloration does not extend into the internode region. Neither internal symptom is completely reliable for diagnosis.

In many sugarcane growing areas, RSD is controlled by eradication of the pathogen in seedcane by heat treatment and the propagation of disease-free seedcane in seed nurseries used in commercial plantings (Gillaspie and Teakle, 1989). In Florida, a two-hour treatment at 50° C is used to establish RSD-free seed farms. Sanitation is necessary to prevent reinfection of the RSD-free seed farms. Florida has been remiss in this control practice because growers have only recently initiated heat treatment programs except for one large grower that has had an RSD control program for many years. Consequently, a large percentage of the commercial fields in Florida have been planted without regard to any RSD control practices. Comstock, et al. (1993) reported RSD incidence, defined as the percentage of infected stalks, varied between cultivars and fields based on limited sampling in Florida.

The effect of disease on yield, pathogen populations found within the stalk, and incidence of plant infection (the percentage of stalks and/or stools infected) all have been used to define the RSD reaction of sugarcane cultivars. Although many sugarcane cultivars have reduced yields due to RSD infection and are considered susceptible, a few cultivars, such as L 60-25, a Louisiana clone, have no yield loss as reported by Grisham (1991) and are considered to be resistant. Davis et al. (1988) reported the yield loss of a cultivar was related to its pathogen population. Damann (1992) reported RSD spread due to mechanical harvesters varied depending on cultivar reaction. The rate and distance of RSD spread from infected plants during mechanical harvest was high, moderate, and nil in susceptible, intermediate, and resistant cultivars, respectively. Comstock et al. (1996) related the rate of RSD spread to the mean number of colonized vascular bundles (CVB) which has been used to estimate relative resistance among sugarcane cultivars. Thus, RSD spreads quicker and reached higher incidences (the percentage of stools infected) in the more susceptible cultivars that have a higher mean number of CVB. Except for a preliminary survey by Comstock et al. (1993), the effect of RSD resistance on disease incidences in commercial growers' fields in Florida has not been determined. The objectives of this research were to determine the incidence of RSD in commercial sugarcane fields that have not been in a RSD-control program and relate the RSD incidence of cultivars to the number of colonized vascular bundles (CVB).

MATERIALS AND METHODS

Sampling Fields for RSD Incidence

Twenty-one cultivars in 200 commercial sugarcane fields were surveyed for their RSD incidence from 1991 through 1994 at Okeelanta Sugar Corporation. Emphasis was placed on selecting cultivars that had been released for several years. Consequently, 69% of the fields surveyed were planted to cultivars released prior to 1988. Only eight fields surveyed were planted with cultivars released after 1990. The majority of fields (184) were planted to one of 13 different cultivars. The number of fields surveyed per cultivar for these 13 ranged from 6 to 40 fields. Since heat-treatment of seedcane was just being initiated at Okeelanta Sugar Corporation in 1991, no seedcane used to plant the fields sampled in this study had been or were derived from heat-treated seedcane. One stalk per stool from 30 stools, were sampled at random from each 16.2 ha field. Sampling occurred across rows skipping several rows between samples to survey a large portion of each field. From each stool, one 0.5 m basal section of stalk was cut next to the soil-line. A 1 cm diameter core was taken from an internode section of 29 of the 30-stalk samples per field as described by Davis et al., 1994. Stalk samples were assayed for *Clavibacter xyli subsp. xyli* using a tissue blot immunoassay (TBIA) according to the method established by Harrison and Davis (1988) as modified by Davis et al. (1994). The developed membranes showed the impression of the vascular bundles with the RSD-colonized vascular bundles (CVB) appearing as blue dots. The average number of CVB per stalk sample and incidence of stalk infection was calculated for each field surveyed.

Data analysis

The mean number of CVB and RSD incidences along with their standard deviations was calculated for all cultivars that had six or more fields surveyed. A two-phase regression between RSD incidence and number of CVB was performed using data from all 200 fields, fitting a quadratic model and a constant line according to SAS (SAS Institute, Inc., 1988).

RESULTS AND DISCUSSION

For the 13 cultivars that had more than six individual fields surveyed, the mean RSD incidence and number of CVB are presented Table 1. Although no field had been planted with heat-treated seedcane, RSD incidences ranged from one to 98% depending on the cultivar. Those cultivars with a low RSD incidence also had a low number of CVB, a parameter which has been used to measure resistance. Three cultivars, CP 72-2086, CP 82-1592 and CL 73-239, all had very low RSD incidences. CP 72-2086, which occupies 18.0% of commercial acreage in Florida, (Glaz, 1996) was released to the industry in 1982 (Miller et al., 1984); therefore, it has had ample opportunity and time to become infected since there was not an RSD control program in place at that time. Based on fewer fields sampled, CL 73-239 had only 2.7% of the stalks infected. Although CL 73-239 may have been initially heat-treated, it has been grown commercially at Okeelanta for eight years without any treatment. In contrast, more than 90% of the stalks sampled were infected in susceptible cultivars, CP 70-1133 and CP 72-1210, which were released in 1977 (Rice et al., 1978) and 1980 (Miller et al., 1981), respectively. CP 80-1827, which is also susceptible based on the number of CVB, had an incidence of 86.4%. CP 80-1827 was released five years after CP 72-2086 (Glaz et al., 1990) and was grown under similar conditions and cultural practices. The wide range of differences among cultivars indicates that cultivar resistance can be used to control RSD.

Since the RSD incidence data of this study relied on infection through normal cultural practices, it should be evaluated carefully. Because exposure to the RSD pathogen takes place primarily during harvest, it may take a period of time for all the plants to become exposed. For this reason, older commercial cultivars were emphasized in the study permitting several years for natural infection to occur. Based on the incidence of RSD in two of the newer commercial cultivars, CP 80-1827 and CP 81-1254, it appears that there was sufficient time to detect susceptibility differences among the cultivars to the RSD pathogen.

The relationship between RSD incidence and number of CVB obtained for all 200 fields is presented in Figure 1. RSD incidences of 90% plus occur for cultivars that have five or more CVB. A very high level of resistance is necessary to prevent any RSD infection. However, a number of cultivars have been grown for years without any RSD control program and maintained a relatively low incidence of disease. Furthermore, field experiments have shown that RSD has a low level of transmission to resistant cultivars during harvest by hand cutting (Comstock et al., 1996). Thus, on a practical level, RSD can be controlled using genetic resistance. The effort and cost of an RSD heat-treatment control program should be reserved for susceptible cultivars that will develop a high RSD incidence and not the resistant cultivars.

Although all the cultivars sampled in this survey were developed without any program to eliminate RSD susceptibility, CL 73-239 and CP 72-2086 appear to be resistant. In 1989, an RSD screening program to eliminate susceptible cultivars was initiated in the breeding and selection program at Canal Point. In time it is hoped that the majority of cultivars released from the program will be resistant. Five recently released cultivars, CP 88-1508, CP 88-1762, CP 88-1834, CP 89-2143, and CP 89-2377 are either resistant or moderately resistant to RSD (Unpublished data).

The RSD incidence and number of CVB data presented here have similarities with RSD spread data reported in other experiments. In this study, RSD incidence was related to cultivar resistance. The highest incidence occurred in cultivars that had the highest susceptibility (number of CVB). Similarly Comstock et al., (1996) and Damann, (1992), reported increased spread in the more susceptible cultivars and the lowest RSD incidences were observed in resistant cultivars.

RSD incidence in the fields surveyed was easily determined using the TBIA. Although no fields had been planted with hot-water-treated seedcane, this survey procedure could be used to determine the effectiveness of such a treatment. Routine surveys would be very effective in helping growers decide which fields, particularly of susceptible cultivars, should be used for seedcane.

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Table 1. Cultivars, number of fields surveyed, RSD incidence and number of colonized vascular bundles (CVB) per stalk sample in commercial fields.

Cultivar	No. of fields	Incidence (%)	Std. Dev.	No. CVB	Std. Dev.
CL 61-620	40	97.7	± 7.40	11.40	±4.66
CL 72-321	13	45.1	±12.32	1.59	±0.95
CL 73-239	9	2.7	± 5.39	0.03	±0.07
CP 70-1133	11	94.4	± 7.44	6.82	±2.55
CP 72-1210	8	92.7	±13.71	7.63	±4.82
CP 72-2086	28	1.4	± 3.90	0.15	±0.58
CP 73-1547	12	14.9	±20.13	0.87	±1.51
CP 78-2114	24	65.1	±30.76	2.45	±1.80
CP 80-1743	28	8.0	±25.60	1.56	±5.62
CP 80-1827	30	86.4	±15.23	7.28	±3.56
CP 81-1254	8	82.6	±17.07	3.19	±0.51
CP 81-1302	6	5.7	± 7.75	0.68	±1.05
CP 82-1592	7	1.0	± 1.66	0.02	±0.02

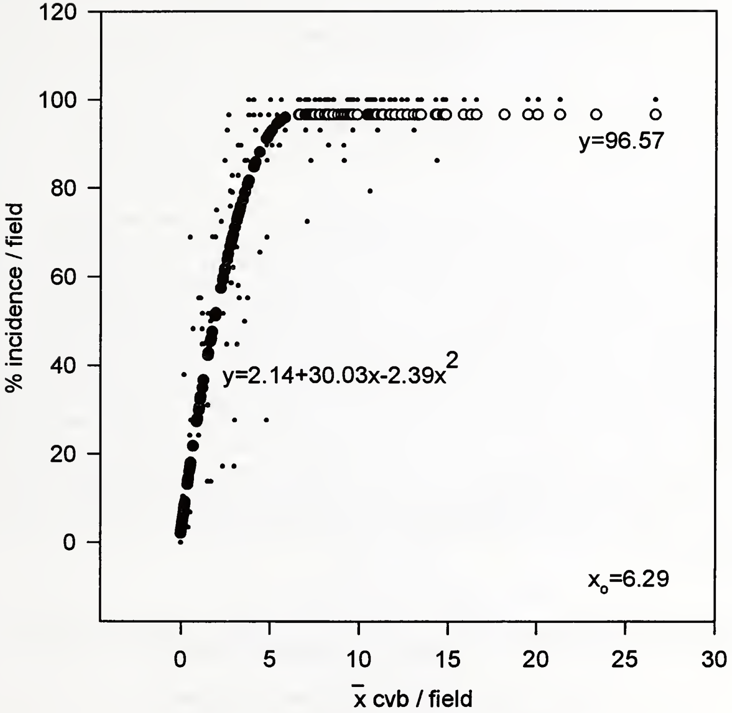

Figure 1. Relationship between ratoon stunting disease (RSD) incidence and the average number of colonized vascular bundles (CVB) in 200 commercial sugarcane fields in Florida.

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AGRICULTURAL ABSTRACTS

EFFECT OF N-HIB CALCIUM AND LIQUID UREA ON SUGARCANE YIELD PARAMETERS

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Research has shown that adding calcium chloride to liquid urea can result in increased nitrogen use efficiency and higher crop yields. Our research was conducted to determine whether N-HIB calcium (provided by Stoller Enterprises, Inc.; composed of 12% calcium as calcium chloride, 1.5% magnesium as magnesium chloride, and a urease inhibitor) can increase nitrogen use efficiency and sugarcane (*Saccharum* spp.) yields. Results showed that adding 45 kg Ca/ha as liquid N-HIB Ca to 135 kg N/ha of liquid urea increased sugar yields by 2950 kg/ha across four years (170, 1220, 830, and 730 kg/ha, respectively, for 1991, 1992, 1993, and 1994). (The increase in sugar with N-HIB Ca application resulted from increased tonnage, which was caused by heavier stalk weights). This compares with a 2250 kg/ha sugar response from increasing nitrogen from 135 to 200 kg N/ha across the four years where calcium was not added. Consequently, adding N-HIB Ca to liquid urea reduced the need for nitrogen fertilizer, which should reduce environmental degradation resulting from nitrogen fertilization. Also, at $0.46/kg of sugar, the 2950 kg/ha of additional sugar across the four years caused by adding 45 kg Ca/ha each year as N-HIB Ca increased the gross crop value by $1,357/ha. It should, therefore, be profitable for producers to use N-HIB Ca in their liquid urea fertilization program if it is priced sufficiently low.

SUGARCANE MANAGEMENT PRACTICES IMPACT AGRICULTURAL CHEMICALS LOSSES IN SURFACE RUNOFF

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An experiment was conducted at St. Gabriel, Louisiana, to quantify the movement of sediment, plant nutrients, and herbicides in surface runoff from sugarcane plots under three different management practices. These data were needed to determine the effectiveness of best management practices (BMPs) on reducing non-point source pollutants from sugarcane fields. Six leveed plots, 0.6 acres in size (nine rows spaced 6-ft apart and 460 feet long), were located on Commerce silt loam (Aeric Fluvaquent, fine-silty, mixed, non-acid, thermic) soil and planted in CP70-321 variety sugarcane in September 1992. Three treatments (high, standard, and low management practices) replicated twice were imposed on the plots. The high management practice consisted of 180, 80, and 180 lbs/A of N, K2O, and P2O5, respectively, with herbicides (atrazine and sencor) applied full broadcast. The standard management practice consisted of 180,

40, and 80 lbs/A of N, K2O, and P2O5, respectively with herbicides applied in a 36-inch band over the row. The low management practice consisted of 60, 0, and 0 lbs/A of N, K2O, and P2O5, respectively with herbicides applied in a 24-inch band over the row. A sump equipped with electric pumps was installed on the low side of each plot. Runoff was measured with a water meter and sampled with an automatic water sampler. Sample collection was triggered when runoff was detected. Runoff samples were analyzed for sediment, nitrogen, phosphorous, potassium, atrazine, and sencor. Average sediment losses differed only slightly among the three treatments with 7.35, 7.25, and 7.10 tons/A measured from high, standard, and low management practices, respectively. Nitrogen loss from the high management practice was 20.8 lbs/A which was 26% more than the 15.9 and 14.9 lbs/A measured from the standard and low management treatments. Phosphorous losses were about the same among treatments with 11.0, 10.1, and 9.8 lbs/A measured from the high, standard, and low management practices, respectively. Potassium losses were similar for the high and standard management treatments at 80.3 and 78.6 lbs/A. However, these losses were 20% higher than the 63.2 lbs/A measured from the low management treatment. Herbicide losses varied considerably among treatments. Atrazine losses were 2.24, 0.82, and 0.48 oz/A from the high, standard and low management treatments, respectively. Thus the loss of atrazine from the high management treatment was 2.7 times more than the standard management treatment while the low management treatment was 41% less than the standard. Sencor losses were 1.12, 0.65, and 0.18 oz/A from the high, standard and low management treatments, respectively. Sencor loss from the high management practice was 1.7 times more than standard management while sencor loss from the low management practice was 72% less than the standard practice. Of the six items tested, the high management practice increased three of them (nitrogen, atrazine, and sencor) considerably above those measured from the standard practice. The low management practice reduced three items (potassium, atrazine, and sencor) considerably below that measured from the standard practice. Thus, management practices impacted the loss of some pollutants (nitrogen, potassium, atrazine, and sencor) in runoff more so than others (sediment and phosphorus).

MECHANICAL HARVESTING EFFECTS ON SUGARCANE CULTIVARS GROWN ON ORGANIC SOILS

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For much of the Florida sugarcane industry's history, manual laborers harvested about 75% of the crop. Now, a rapid change is complete and 100% of Florida's milled sugarcane (a complex hybrid of *Saccharum* spp.) is harvested by machines. The sugarcane cultivar development program at Canal Point (CP) now routinely subjects promising experimental clones to commercial mechanical harvesters. However, more information was needed on responses to mechanical harvesting of many already released sugarcane cultivars as 75% of Florida's harvest rapidly changed from manual to mechanized harvesting. The purpose of this study was to test, when

subjected to mechanized harvesting, the plant-cane through second-ratoon yields of established and promising sugarcane cultivars in Florida. Three experiments were planted in the fall of 1991, one on land previously subjected to a summer flooded fallow period, and two on land subjected to a successive sugarcane rotation. A major concern in Florida is that root damage during a mechanical harvest will reduce yields of subsequent ratoons. Therefore, cultivars whose cane-tonnage yields were highest relative to the other cultivars in the ratoon crops were categorized as well adapted to mechanical harvesting. Significant crop (plant-cane, first-ratoon, and second-ratoon crops) x cultivar interactions in two experiments suggested that mechanical harvesters did not affect all cultivars similarly. Among nine cultivars that were planted in all three experiments, CP 80-1827 had the highest yields. Four cultivars that yielded similarly to each other, but lower than CP 80-1827, were CP 70-1133, CP 72-2086, CP 85-1308, and CP 85-1382. CP 80-1743 and CP 84-1198 were not planted in each of the three experiments but yielded well where planted. Except for an extreme negative case with CP 82-1172, cultivar characteristics such as ability to remain upright or to maintain straight stalks after lodging were not good predictors of which cultivars would produce high ratoon yields following mechanical harvests.

BREEDING FOR LEAF PUBESCENCE IN SUGARCANE TO CONTROL BORERS

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Leaf pubescence is a known morphological plant character that imparts resistance to insects in several crops. Although there is no known commercial sugarcane cultivar with pubescent leaves, 28 clones of *Saccharum robustum* have been identified from the U.S. Collection of Sugar Cane and Related Grasses having this character. Tests have shown that sugarcane borer lay fewer eggs and egg masses are smaller on pubescent leaves. Also, yellow sugarcane aphids populations are smaller on pubescent sugarcane leaves. Crosses to incorporate pubescence into commercial cultivars began in 1984. A total of 3,526 plants growing in the field were evaluated for the pubescent trait. About 25% of these plants exhibited some level of pubescence. Expression of pubescence varied greatly between crosses and among progenies of the same cross. Some plants exhibited pubescence on one leaf surface but not the other, and at different densities. Differences were also observed within the same leaf surface, being extremely pubescent close to the base (about 1/3 of the leaf length) to entirely absent on the remaining leaf area. A few of the pubescent hybrids exhibited good brix (17-21) but have not been tested for other agronomic traits desirable in a commercial cultivar. The great advantage of pubescence as an insect resistant character in a breeding program is its visibility; no additional tests are needed to determine its effectiveness. A pubescent cultivar could be highly effective in reducing loses by sugarcane borers and possibly to other pests of sugarcane.

REVISITING CROP LOSS TO SUGARCANE BORER

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The effect of an artificially induced sugarcane borer infestation on the yield of 23 Louisiana varieties was determined in a series of experiments conducted between 1989 and 1994. The experimental design employed each year was a split-plot with insecticide treated versus untreated plots as main units and varieties as subunits arranged as a randomized complete block

with 4 replications. Each plot consisted of three rows wide (18 feet), 16 feet long. Data collected included millable stalk counts, height of stalks at harvest, plot weight, and sucrose content. Sugarcane borer damage was expressed as percent internodes bored. Using cluster analysis, three resistance groups were identified with the following ratios of percent reduction in lbs of sugar/ton of cane (CRS) per one percent bored internodes: resistant = .22; intermediate = .41; and susceptible = .79. Three resistance groups were identified with the following ratios of percent reduction in tons of cane/acre per one percent bored internodes: resistant = -.63; intermediate = .1; and susceptible = .67. Four resistance groups were identified with ratios of percent reduction in sugar/acre per one percent bored joints: resistant = -.03; intermediate resistant = .50; intermediate susceptible = .61;, and susceptible = .95. These data indicated that losses in both the field (reduction in tonnage) and factory (reduction in CRS) were important. Ultimately, the relative importance of field to factory loss was dependent upon the variety. For example, the ratings assigned to the variety CP 70-321 changed from resistant when categorized on field losses to susceptible when categorized for factory losses.

WIREWORM POPULATIONS IN SUGARCANE FIELDS AFTER DIFFERENT CROPPING SYSTEMS

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Wireworms are ubiquitous soil insect pests of both vegetable crops and sugarcane grown in southern Florida. Soil insecticides are routinely applied at planting for wireworm control. The wireworm, *Melanotus communis*, is the most important species of wireworm attacking Florida sugarcane. Sugarcane fields in Florida were sampled for *M. communis* wireworms from 1993 to 1996. These sugarcane fields were planted after sugarcane, rice harvested once, or ratooned rice (two crops). Rolled oat bait samples and soil samples around seedpieces were taken to sample wireworms when the sugarcane was planted. Soil samples around sugarcane plants were also taken at 5, 10, and 15 months after planting. A total of 30 sugarcane fields were sampled. Bait samples and soil samples both showed that more *M. communis* wireworms were present in sugarcane fields planted after sugarcane than in sugarcane fields planted after rice (one or two crops). These data are consistent with an earlier study which showed that soil insecticides may not always be necessary when planting sugarcane after rice due to low *M. communis* populations at sugarcane planting. During the 5 to 15 month period after sugarcane planting, more *M. communis* wireworms were found in sugarcane fields planted after sugarcane than sugarcane fields planted after rice (one or two crops). These data show that rice is beneficial to sugarcane growers by reducing *M. communis* populations in the subsequent sugarcane crop both at planting and during 5 to 15 months after planting.

EVALUATING COST OF ALTERNATIVE SUGARCANE HARVESTING SYSTEMS IN LOUISIANA

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Louisiana's quest for greater efficiency in delivering sugarcane to mills has re-ignited the industries's interest in the use of chopper harvesters. While the efficiency of the billeted system is being tested, the cost of operating a combine system in Louisiana has not been established. Louisiana's cultivation practices and short harvest season significantly affect the amount of equipment needed and its use. The cost of owning and operating a harvesting system is extremely dependent upon the farm size, distance to mills and management. The evaluation is based on a computer simulation model. The model uses the Mississippi State Budget Generator to estimate variable and fixed cost for each operation. Information for a specific farm is used to estimate the minimal total cost for combine and soldier systems. Any system or combination of systems can be evaluated. This new approach of customizing a budgeting program to the specific situation will provide more specific cost information for an individual producer's situation.

INTRASPECIFIC GENOMIC VARIATION WITHIN *XANTHOMONAS ALBILINEANS,* THE SUGARCANE LEAF SCALD PATHOGEN

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The recent outbreak of leaf scald disease of sugarcane in Florida and the first occurrence of the disease in Louisiana and Texas can be attributed to the introduction of a specific genetic variant of the pathogen, *Xanthomonas albilineans.* To help assess the potential for additional introductions, a study of the worldwide genetic variation of the pathogen was undertaken. DNA fingerprints of 218 strains from 27 countries were obtained by digesting the DNA of each strain with the rare-cutting restriction enzyme, *Spe 1*, and separating the resultant fragments by pulse-field gel electrophoresis. Fifty-four different DNA banding patterns (fingerprints) were observed representing distinct haplotypes. The molecular weight of each band was measured and a total of 102 bands identified. Binary scores for the presence or absence of the bands were used to calculate Dice's coefficient (S) for the pair-wise similarity among haplotypes, and the distances (1-S) between all pairs were then analyzed for clusters of haplotypes by the unweighted pair-group method using arithmetic averages. Eight clusters, considered to represent individual genetic groups, were found; five were comprised of multiple haplotypes representing numerous strains and three were comprised of single haplotypes representing one strain each. Limited geographic distribution of groups was apparent. All strains examined from Florida, Louisiana, Texas and Hawaii belonged to one of two genetic groups that appeared to be more closely related to one another than to the remaining six groups. Considering the apparent pathological diversity between the two groups presently in the United States, the possibility exists that strains of the pathogen belonging to exotic groups could significantly harm the sugarcane industry if they were introduced into the United States. Likewise, the industries in other countries are also at risk.

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NEW OPPORTUNITIES IN INSECTICIDE MANAGEMENT OF STALK BORERS IN LOUISIANA SUGARCANE

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Evaluation of insecticides against the key pest of sugarcane in Louisiana, the sugarcane borer, *Diatraea saccharalis* (F.) has led to submission of Section 18 requests and approval by EPA in the 1996 production season for CONFIRM and KARATE. The insect growth regulator (IGR) has the common name of tebufenozide and is in the Diacylhydrazine group of new insecticidal chemistry. The pesticide mimics the ecdysone chemical used in the natural molting process of certain Lepidopterous insects. As such, it is so specific that few other insects and organisms are affected. The degree of sensitivity of the sugarcane borer to this IGR is indicated by the LC-50 value (dose concentration necessary to kill 50% of the insects) of 0.17 ppm compared to 2.6 ppm for the beet armyworm, a major pest in cotton also controlled by tebufenozide (CONFIRM). The new IGR is the first insecticide effective for borer control with a high level of compatibility for parasite release and enhancement of biological control programs. Experimental data also indicates an enhanced effective residual control period with succeeding applications, partially due to less detrimental impact on beneficial arthropods with CONFIRM than with other insecticides. Federal approval has been received through cooperative work with the USDA-ARS to rear and field - release the exotic borer parasite *Cotesia chilonis* in conjunction with these insecticide studies. In contrast with other pyrethroids, KARATE not only does not buildup infestations of the yellow sugarcane aphid, it suppresses them. These newly labeled insecticides show a more positive fit, than the older insecticide chemistry, for use in an industry that has a history of insecticide environmentally related problems with fish and other wildlife. The opportunities also are greatly expanded too more fully utilize biological control during the time of the year when insecticidal control of the sugarcane borer is required.

PREDICTING MARKET SURVIVAL OF FLORIDA SUGARCANE CULTIVARS

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The Florida Sugarcane Industry, located in the northern Everglades and adjacent to Lake Okeechobee, has progressed from 1928 to the current time. Since 1928, approximately 33 principal cultivars have occupied at least 1% of the acreage used for production each year. Measures of diversity of sugarcane cultivars grown in Florida fluctuate over time. Older cultivars are replaced by newer cultivars, and the length of time a cultivar is grown varies. Cultivar value can be measured by its market longevity. Factors which are known to influence the decline of a cultivar in the market include decreases in vigor and yield, increased disease susceptibility, and improvement in yields of new cultivars released by plant breeding programs. However, these factors cannot be utilized at a cultivar's release to predict how long the cultivar will remain in the market. This paper examines how sugarcane cultivars can be judged based upon how long they were maintained in the market and whether factors that can be measured within a few years after cultivar release can predict the market longevity of the newly released cultivar.

Key words: Censored observations, Kaplan-Meier survival function, Cox regression, Simpson Diversity Index, survival analysis, time series.

DRY TOP ROT: CULTIVAR REACTION AND HERITABILITY OF RESISTANCE

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Clones were screened for their reaction to dry top rot, a disease detected in Florida in 1991 that is caused by the soil-borne pathogen, *Ligniera vasculorum*. Disease reactions were based on disease incidence and severity resulting from the natural infection of plants planted in a field where the soil-borne pathogen was present. Of the 29 CP-clones and 27 CL-clones evaluated: 4 clones (CP 88-1614, CP 88-1196, CP 75-1553, and one CL clone) were susceptible having above 24% of the stalks infected; 3 clones (CP 81-1254 plus two CL clones) were moderately susceptible with 10-16% stalks infected; 15 clones had between 0.5 to 8% stalks infected and 36 clones did not develop dry top rot symptoms. Heritability of dry top rot resistance was determined using progeny of 17 families resulting from seven female parents (3 resistant, 1 intermediate, and 3 susceptible) crossed with five male parents (1 intermediate and 4 resistant). Seedling progeny were transplanted in the field where the pathogen was present. Since little disease was evident in the plant crop, the incidence of dry top rot was determined in the first ratoon crop. A heritability value ($h2 = 0.47$) was obtained from the regression of the progeny disease incidence on their mid-parent dry top rot incidence.

REARING AND RELEASING *COTESIA FLAVIPES* FOR SUGARCANE BORER CONTROL IN FLORIDA

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The braconid parasitoid *Cotesia flavipes* Cameron was introduced into Florida during the early 1960s in hopes of boosting natural control of the sugarcane borer, *Diatraea saccharalis* (Fab.). Within several years, the parasitoid was well established and widespread throughout the sugarcane growing area in south Florida. Economic infestations of the borer can develop anytime between March and November in Florida. Surveys during the 1980s showed that population levels of the parasitoid may often be too low to detect during March through July but that they increase dramatically during late summer and fall, to the point that 50 to 60% or more borers may often be parasitized by late October or November. *Cotesia* can be mass-reared and introduced into cane fields to enhance natural control before economic borer infestations develop, and releases

of the parasitoid can sometimes be used successfully as an emergency control tactic for borer outbreaks. United States Sugar Corporation established an insectary and has instigated a *Cotesia* rearing and release program for sugarcane borer control in Florida.

ENGINEERING SUGARCANE FOR RESISTANCE TO SUGARCANE MOSAIC VIRUS

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Of the various strains of sugarcane mosaic virus (SCMV) found in the US, strain H causes the most significant losses. As it is now possible to control plant viruses very effectively by genetic engineering, we are using this approach to control this virus. We have established a collection of seven SCMV strains originally found in sugarcane in the US. This includes SCMV strains A, B, D, E, and the sorghum mosaic virus strains H, I, and M. These viruses have been propagated on Sorghum bicolor cv. rio and purified. Cloned cDNAs representing approximately 2.0 kb of 3¢ termini, obtained after RT-PCR using a poly T primer and a degenerate primer located in the NIb gene, have been obtained and sequenced for each of these strains. This sequence data has allowed us to develop a rapid RT-PCR based RFLP strain discrimination assay. We have produced chimeric constructs made by fusion of the coat protein gene of strain H with the maize ubiquitin promoter. These constructs are used in biolistic co-transformation experiments using the bar gene or the nptII gene as the selectable marker. We have regenerated over 1,600 plants with this system. Plants regenerating roots on selection media are being screened for the presence of the transgenes, and we have identified more than 200 plants in which the coat protein gene has been introduced. These transgenic plants have been inoculated up to four times with strain H. The results of these experiments will be reported.

ENHANCEMENT OF BARN OWL POPULATIONS IN THE EVERGLADES AGRICULTURAL AREA AS A MEANS OF SUSTAINABLE RODENT CONTROL

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Consisting of nearly 750,000 acres of sugarcane, rice, sod, and vegetable crops, the Everglades Agricultural Area (EAA) of south Florida provides a haven for numerous rodent pests, particularly rats and rabbits. Frequently, due to insufficient pressure from naturally existing predatory populations, rodent pests cause economic damage to these crops, especially sugarcane. Efforts must then be made to control their populations using chemical rodenticides. With sustainable agriculture being the ultimate goal, nonchemical methods are presently being sought. The indigenous barn owl (*Tyto alba*) has been demonstrated to be very effective in preying on such agricultural pests, with an established nesting pair being capable of eliminating in excess of 1,000 rodents per year. However, barn owl populations in south Florida remain far below optimum due to a general lack of suitable nesting structures in the virtually treeless and structureless EAA and urban encroachment in adjacent coastal pinelands. A research project to investigate the colonization of barn owl nesting boxes on the perimeters of sugarcane fields in the EAA has been initiated. Nesting box design and placement are two major variables of interest. Successful colonization of established artificial nesting sites would prove mutually beneficial to both owls and growers. Wildlife habitat would be enhanced for a desirable species and a self-sustaining method of rodent control could be achieved in an environmentally sound manner.

MANUFACTURING ABSTRACTS

CONTRIBUTION OF FIELD SOIL AND CANE TRASH TO SUGARCANE JUICE COLOR

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During routine sediment tests conducted on cane juice samples from sugarcane stalks containing varying amounts of field soil and cane trash (0, 10, 20, and 30%, alone and in combination, by weight of cane stalks), a wide range in color was noted in the supernatant which did not correlate to the sediment load in the juice. From these observations, a series of experiments was conducted to quantitate the effect of field soil and cane trash on juice color. Results confirmed the deleterious effect of cane trash, to include sugarcane leaf blades and sheaths but no tops, both desiccated and fresh, on juice color, with an approximate five-fold increase in color over the range in cane trash studied. The effect of cane trash on color appeared nonlinear: color increased at a greater rate with each incremental increase in the level of cane trash. On the other hand, field soil (Mhoon silty clay loam with approximately 33% moisture) alone showed a decolorizing effect, due, undoubtedly, to the ion exchange properties of the soil type. Further, the effect of field soil on color appeared linear: a decrease of 1.6% in color for each 1% increase in field soil added to the cane sample. Finally, field soil and cane trash in combination (equal amounts of both field soil and cane trash by weight up to a total of 30% by weight of cane stalks) showed the opposing effects of the two components: color increased with an increase in total trash but not as much as with the cane trash alone. The overall effect was nonlinear. In summary, it appears that cane trash has a greater effect on juice color than does field soil; however, field soil is still very deleterious to sugar processing, i.e., increases volume and sugar loss in filter-press mud, contributes turbidity, increases ash, wears equipment, and lowers burning efficiency of bagasse, and should be avoided in harvested cane even if it does help to decolorize the cane juice.

LUBRICATION METHOD IMPROVEMENTS

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The average food industry facility has approximately 5400 bearings. Over 90% are grease lubricated on a daily, weekly, or monthly frequency. Oil lubricated components e.g. chains, cylinders, and valves are not included in this category but present similar opportunities. Alternative methods e.g. single point kits, manual and automated lubrication systems, mobile lube trucks, and carts along with bulk dispensing systems may be employed to impact current method costs. These devices permit the food industry manager to gain control over these cost areas and shift dollars to the bottom line. This paper will identify the costs linked to the manual lubrication method, explore automated solutions offered by alternative methods, and quantify the financial impact of a method change. Benefits that may be achieved include reduced manufacturing costs,

improved plant safety, and protection of the environment.

IMPROVING SUGAR RECOVERY WITH SUGAR PROCESS CHEMICALS

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Sugar process chemicals have been available to the industry for many years. Their development has been directed towards the improvement of recovery and quality throughout the factory. To enhance sugar recovery, large outlays of capital investment in mechanical and physio-mechanical process systems are now being proposed and evaluated. A more advantageous approach would be to reevaluate new developments in sugar process chemical technology, improving factory efficiencies and recovery with little or no capital investment. Several process chemical applications are described, from a technical standpoint, evaluating the economics of using process chemicals to increase the amount of sugar available for recovery, and showing a positive return on investment to the factory.

IMPACT OF THE CLEAN AIR ACT IN SUGAR MILLS

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This paper presents an overview of the Clean Air Act, and how the State of Florida has been implementing the rules and regulations from this Act since the 70's, requiring special attention and large investments from the industry throughout the years. The impact of the amendments of this law is becoming more and more significant, since the industry must comply with regulations which call for limits on the emissions of air pollutants, which could lead us into the installation of very expensive and advanced equipment we can not afford. The Title V of the Clean Air Act is requiring construction permits for some facilities, and is also calling for the accounting of not only boilers' emissions, but for all emissions including fugitive ones of these facilities. The Section 129, now under preparation, intends to consider bagasse boilers as incinerators, then requiring Maximum Available Control Technology to achieve compliance with the new standards.

THE "A.B.C. PROCESS" FOR THE DIRECT PRODUCTION OF REFINED SUGAR FROM CANE MIXED JUICE

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A report on the results of the "A.B.C. PROCESS" for the direct production of refined sugar from cane mixed juice. The results for this report are based upon data from independent laboratory analysis on over 130 different test runs. The "A.B.C. PROCESS" is a three (3) step process, comprised of continuous screening, ultra-clarification and adsorption, for the cleaning and decolorizing of cane juice and syrup. Through the screening and ultra-clarification steps all suspended solids, proteins, HMW compounds, molds, yeasts and bacteria are removed. In addition, the adsorption removes phenolic compounds and caramels to produce an excellent

decolorized syrup. The operating cost of this process, including labor, chemicals, energy, maintenance and replacement of membranes and adsorbent is lower than the traditional clarification methods in the raw factory. The A.B.C. Process removes from the mixed juice over 99% Dextrans, 98% Ash, 99% Color, 98% turbidity, 99% Starch and produces a final sugar with less than 0.04% reducing sugars and lower than 35 IC color. As the different tests have shown the "A.B.C. PROCESS" is a robust, predictable, economical and efficient method for the direct production of refined sugar.

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS EDITORIAL POLICY

Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

Frequency of publication:

The Journal will appear at least once a year. At the direction of the Joint Executive Committee, the Journal may appear more frequently. Contributed papers not presented at a meeting may be reviewed, edited, and published if the editorial criteria are met.

Editorial Committee:

The Editorial Committee shall be composed of the Managing Editor, Technical Editor for the Agricultural Section, and Technical Editor for the Manufacturing Section. The Editorial Committee shall regulate the Journal content and assure its quality. It is charged with the authority necessary to achieve these goals. The Editorial Committee shall determine broad policy. Each editor will serve for three years; and may at the Joint Executive Committee's discretion, serve beyond the expiration of his or her term.

Handling of manuscripts:

Four copies of each manuscript are initially submitted to the Managing Editor. Manuscripts received by the Managing Editor will be assigned a registration number determined serially by the date of receipt. The Managing Editor writes to the one who submitted the paper to inform the author of the receipt of the paper and the registration number which must be used in all correspondence regarding it.

The Technical Editors obtain at least two reviews for each paper from qualified persons. The identities of reviewers must not be revealed to each other nor to the author during the review process. Instructions sent with the papers emphasize the necessity for promptness as well as thoroughness in making the review. Page charges will be assessed for the entire manuscript for non-members. Members will be assessed for those pages in excess of ten (10) double spaced Times New Roman (TT) 12 pt typed pages of 8 1/2" x 11" dimension with one (1) inch margins.

When a paper is returned by reviewers, the Technical Editor evaluates the paper and the recommendations of the reviewers. If the paper as received is recommended by two reviewers for publication in the Journal, it is sent to the Managing Editor. At this time, the Managing Editor will request a final version in hardcopy and on diskette in WordPerfect format from the corresponding author.

If major revisions are recommended, the Technical Editor sends the paper to the author for this purpose, along with anonymous copies of reviewers' recommendations. When the paper is returned to the Technical Editor, he/she will judge the adequacy of the revision and may send the paper back to any reviewer for further review. When the paper has been revised satisfactorily, it is sent to the Managing Editor for publishing. A paper sent to its author for revision and held more than 6 months will be given a new date of receipt when returned. This date will determine the priority of publication of the paper.

A paper rejected by one reviewer may be sent to additional reviewers until two reviewers either accept or reject the paper. If a paper is judged by two or more reviewers as not acceptable for the Journal, theTechnical Editor returns it to the author along with a summary of the reasons given by the reviewers for the rejection. The registration form for the paper is filled out and returned to the Managing Editor along with copies of the reviewers' statements and a copy of the Technical Editor's transmittal letter to the author. The names of all reviewers must be shown on the registration form transmitted to the Managing Editor.

After the review process is completed, each accepted paper is read by the Technical Editor to correct typographical, grammatical, and style errors and to improve the writing where this seems possible and appropriate, with special care not to change the meaning. Instructions for the printer are inserted as needed. The papers are sent by the Technical Editor to the Managing Editor who notifies the authors of this fact and of the probable dates of publication.

Preparation of papers for publication:

Papers sent by the Technical Editor to the Managing Editor are prepared for printing according to their dates of original submittal and final approval and according to the space available in the next issue of the Journal.

The paper is printed in the proper form for reproduction, and proofs are sent to the authors for final review. When the proofs are returned, all necessary corrections are made prior to reproduction. The author will be notified at the appropriate time to order reprints at cost.

Any drawings and photographs for the figures in the paper are "scaled" according to their dimensions, the size of lettering, and other factors. They are then sent to the printer for camera work. Proofs of the illustrations are sent to the authors. Any changes requested at this stage would be expensive and authors will be expected to pay the cost of such changes.

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RULES FOR PREPARING PAPERS TO BE PRINTED IN THE JOURNAL OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

Format

Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION (OR RESULTS AND DISCUSSION), CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized. Scientific names shall be italicized.

All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. If using WordPerfect, set the bottom margin at 0.5 inches. This will set the page number at 0.5 inches and the final line of text at 1 inch from the bottom margin. Exactness in reproduction can be insured if electronic copies of the final versions of manuscripts are submitted. Authors are encouraged to contact the managing editor for specifics regarding software and formatting software to achieve ease of electronic transfer.

Authorship

Name of the authors, institution or organization with which they are associated, and their locations should follow the title of the paper.

Abstract

The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

Tables

Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Use TAB function rather than SPACE BAR to separate columns of a table.

Figures

Number the figures consecutively and refer to them in the text as Figure 1, Figure 2, etc. Each figure must have a legend. Figures must be of sufficient quality to reproduce legibly.

Drawings & Photographs

Drawings and photographs must be provided separately from the text of the manuscript and identified on the back of each. Type figure numbers and legends on separate pieces of paper with proper identification. Drawings and photographs should be of sufficient quality that they will reproduce legibly.

Reference Citations

The heading for the literature cited should be REFERENCES. References should be arranged such that the literature cited will be numbered consecutively and placed in alphabetical order according to the surname of the senior author. In the text, references to literature cited should be made by name of author(s) and year of publication from list of references. Do not use capital letters in the titles of such articles except in initial words and proper names, but capitalize words in the titles of the periodicals or books.

Format Example

ITCHGRASS *(ROTTBOELLIA COCHINCHINENSIS) CONTROL* IN SUGARCANE WITH POSTEMERGENCE HERBICIDES

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ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

RESULTS AND DISCUSSION

Table 1. Visual itchgrass control and sugarcane injury as influenced by over-the-top herbicide application at Maringouin and Thibodaux, LA, 1989.

CONCLUSIONS

ACKNOWLEDGMENTS

REFERENCES

GUIDELINES FOR PREPARING PAPERS FOR JOURNAL OF ASSCT

The following guidelines for WordPerfect software are intended to facilitate the production of this journal. Authors are strongly encouraged to prepare their final manuscripts with WordPerfect 6.0 or 6.1 for Windows or Dos. Please contact the Managing Editor if you will not use one of those software packages.

Paper & Margins: All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. To achieve this with WordPerfect, set the top, left, and right margins at one inch. However, set the bottom margin at 0.5 inches. This will place the page number at 0.5 inches and the final line of text at one inch.

Fonts: Submit your document in the Times New Roman (TT) 12pt font. If you do not have this font, contact the Managing Editor.

Alignment: Choose the full alignment option to prepare your manuscript. The use of SPACE BAR for alignment is not acceptable. As a general rule SPACE BAR should only be used for space between words and limited other uses. Do not use space bar to indent paragraphs, align and indent columns, or create tables.

Do not use hard returns at the end of sentences within a paragraph. Hard returns are to be used when ending paragraphs or producing a short line.

Place tables and figures within the text where you wish them to appear. Otherwise, all tables and figures will appear after your References section.

Styles: ***Italicize*** scientific names. Do not use underline.

Tables: Use Tab stops and the **Graphics** line draw option when constructing tables. Avoid the space bar to separate columns (see alignment). All lines should begin with the left most symbol in their left most column and should end with the right most symbol in their right most column.

Citations: When producing Literature Citations, use the indent feature to produce text as below.

1. Smith, I. M., H. P. Jones, C. W. Doe, 1991. The use of multidiscipline approaches to control rodent populations in plants. Journal of American Society of Plant Management. 10:383-394.

Journal American Society of Sugar Cane Technologists, Vol. 17, 1997

CONSTITUTION OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

As Revised and Approved on June 21, 1991
As Amended on June 23, 1994
As Amended on June 15, 1995

ARTICLE I

Name, Object and Domicile

Section 1. The name of this Society shall be the American Society of Sugar Cane Technologists.

Section 2. The object of this society shall be the general study of the sugar industry in all its various branches and the dissemination of information to the members of the organization through meetings and publications.

Section 3. The domicile of the Society shall be at the office of the General Secretary-Treasurer (as described in Article IV, Section 1).

ARTICLE II

Divisions

The Society shall be composed of two divisions, the Louisiana Division and the Florida Division. Each division shall have its separate membership roster and separate officers and committees. Voting rights of active and honorary members shall be restricted to their respective divisions, except at the general annual and special meetings of the entire Society, hereinafter provided for, at which general meetings active and honorary members of both divisions shall have the right to vote. Officers and committee members shall be members of and serve the respective divisions from which elected or selected, except the General Secretary-Treasurer who shall serve the entire Society.

ARTICLE III

Membership and Dues

Section 1. There shall be five classes of members: Active, Associate, Honorary, Off-shore or Foreign, and Supporting.

Section 2. Active members shall be individuals residing in the continental United States actually engaged in the production of sugar cane or the manufacture of cane sugar, or research or education pertaining to the industry, including employees of any corporation, firm or other organization which is so engaged.

Section 3. Associate members shall be individuals not actively engaged in the production of sugar cane or the manufacture of cane sugar or research pertaining to the industry, but who may be interested in the objects of the Society.

Section 4. Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to 5 living Honorary members assigned to the two Divisions jointly.

Section 5. Off-shore or foreign members shall be individuals not residing in the continental United States who may be interested in the objects of the Society.

Section 6. Supporting members shall be persons engaged in the manufacturing, production or distribution of equipment or supplies used in conjunction with production of sugar cane or cane sugar, or any corporation, firm or other organization engaged in the production of sugar cane or the manufacture of cane sugar, who may be interested in the objects of the Society.

Section 7. Applicants for new membership shall make written application to the Secretary-Treasurer of the respective divisions, endorsed by two members of the division, and such applications shall be acted upon by the division membership committee.

Section 8. Minimum charge for annual dues shall be as follows:

Active Membership	$10.00
Associate Membership	$25.00
Honorary Membership	NONE
Off-shore or Foreign Membership	$20.00
Supporting Membership	$50.00

Each Division can assess charges for dues more than the above schedule as determined by the Division officers or by the membership at the discretion of the officers of each Division.

Dues for each calendar year shall be paid not later than 3 months prior to the annual meeting of the member's division. New members shall pay the full amount of dues, irrespective of when they join. Any changes in dues will become effective in the subsequent calendar year.

Section 9. Dues shall be collected by each of the Division's Secretary-Treasurer from the members in their respective divisions. Unless and until changed by action of the Joint Executive Committee, 50 percent of the minimum charge for annual dues, as described in Section 8 for each membership class, shall be transmitted to the office of the General Secretary-Treasurer.

Section 10. Members in arrears for dues for more than a year will be dropped from membership after thirty days notice to this effect from the Secretary-Treasurer. Members thus dropped may be reinstated only after payment of back dues and assessments.

Section 11. Only active members of the Society whose dues are not in arrears and honorary members shall have the privilege of voting and holding office. Only members (all classes) shall have the privilege of speaking at meetings of the Society.

ARTICLE IV

General Secretary-Treasurer and Joint Executive Committee

Section 1. The General Secretary-Treasurer shall serve as Chief Administrative Officer of the Society and shall coordinate the activities of the divisions and the sections. He or she will serve as ex-officio Chairperson of the Joint Executive Committee and as General Chairperson of the General Society Meetings, and shall have such other duties as may be delegated to him or her by the Joint Executive Committee. The office of the General Secretary-Treasurer shall be the domicile of the Society.

Section 2. The Joint Executive Committee shall be composed of the elected members of the two division Executive Committees, and is vested with full authority to conduct the business and affairs of the Society.

ARTICLE V

Division Officers and Executive Committee

Section 1. The officers of each division of the Society shall be: a President, a First Vice-President, a Second Vice-President, a Secretary-Treasurer or a Secretary and a Treasurer, and an Executive Committee composed of these officers and four other members, one from each section of the Division (as described in Section 3 of Article VII), one elected at large, and the President of the previous Executive Committee who shall serve as an Ex-Officio member of the Division Executive Committee. The office of the Secretary-Treasurer in this constitution indicates either the Secretary-Treasurer, or the Secretary and the Treasurer.

Section 2. These officers, except Secretary-Treasurer, shall be nominated by a nominating committee and voted upon before the annual division meeting. Notices of such nominations shall be mailed to each member at least one month before such meeting. Ballots not received before the annually specified date will not be counted.

Section 3. The Secretary-Treasurer shall be appointed by and serve as a non-voting member at the pleasure of the Division Executive Committee. The Secretary-Treasurer may not hold an elected office on the Executive Committee.

Section 4. The duties of these officers shall be such as usually pertain to such officers in similar societies.

Section 5. Each section as described in Article VII shall be represented in the offices of the President and Vice-President.

Section 6. The President, First Vice-President, and Second Vice-President of each Division shall not hold the same office for two consecutive years. Either Section Chairperson (as described in Section 3 of Article VII) may hold the same office for up to two consecutive years. The terms of the other officers shall be unlimited.

Section 7. The President shall be elected each year alternately from the two sections hereinafter provided for. In any given year, the Presidents of the two Divisions shall be nominated and elected from different sections. The President from the Louisiana Division for the year beginning February, 1970, shall be nominated and elected from the Agricultural Section. The president from the Florida Division for the year beginning February, 1970, shall be nominated and elected from the Manufacturing

Section.

Section 8. Vacancies occurring between meetings shall be filled by the Division Executive Committee.

Section 9. The terms "year" and "consecutive year" as used in Articles V and VI shall be considered to be comprised of the elapsed time between one annual division meeting of the Society and the following annual division meeting of the Society.

ARTICLE VI

Division Committees

Section 1. The President of each division shall appoint a committee of three to serve as a Membership Committee. It will be the duty of this committee to pass upon applications for membership in the division and report to the Secretary-Treasurer.

Section 2. The President of each division shall appoint each year a committee of three to serve as a Nominating Committee. It will be the duty of the Secretary-Treasurer of the Division to notify all active and honorary members of the Division as to the personnel of this committee. It will be the duty of this committee to receive nominations and to prepare a list of nominees and mail this to each member of the Division at least a month before the annual meeting.

ARTICLE VII

Sections

Section 1. There shall be two sections of each Division, to be designated as:

1. Agricultural
2. Manufacturing

Section 2. Each active member shall designate whether he or she desires to be enrolled in the Agricultural Section or the Manufacturing Section.

Section 3. There shall be a Chairperson for each section of each Division who will be the member from that Section elected to the Executive Committee. It will be the duty of the Chairperson of a section to arrange the program for the annual Division meeting.

Section 4. The Executive Committee of each Division is empowered to elect one of their own number or to appoint another person to handle the details of printing, proof reading, etc., in connection with these programs and to authorize the Secretary-Treasurer to make whatever payments may be necessary for same.

ARTICLE VIII

Meetings

Section 1. The annual General Meeting of the members of the Society shall be held in June each year on a date and at a place to be determined, from time to time, by the Joint

Executive Committee. At all meetings of the two Divisions of the Society, five percent of the active members shall constitute a quorum. The program for the annual meeting of the Society shall be arranged by the General Secretary-Treasurer in collaboration with the Joint Executive Committee.

Section 2. The annual meeting of the Louisiana Division shall be held in February of each year, at such time as the Executive Committee of the Division shall decide. The annual meeting of the Florida Division shall be held in September or October of each year, at such time as the Executive Committee of that Division shall decide. Special meetings of a Division may be called by the Executive Committee of such Division.

Section 3. Special meetings of a Section for the discussion of matters of particular interest to that Section may be called by the President upon request from the respective Chairperson of a Section.

Section 4. At Division meetings, 10 percent of the active division members and the President or a Vice-President shall constitute a quorum.

ARTICLE IX

Management

Section 1. The conduct and management of the affairs of the Society and of the Divisions including the direction of work of its special committees, shall be in the hands of the Joint Executive Committee and Division Executive Committees, respectively.

Section 2. The Joint Executive Committee shall represent this Society in conferences with the American Sugar Cane League, the Florida Sugar Cane League, or any other association, and may make any rules or conduct any business not in conflict with this Constitution.

Section 3. Four members of the Division Executive Committee shall constitute a quorum. The President, or in his or her absence one of the Vice-Presidents, shall chair this committee.

Section 4. Two members of each Division Executive Committee shall constitute a quorum of all members of the Joint Executive Committee. Each member of the Joint Executive Committee, except the General Secretary-Treasurer, shall be entitled to one vote on all matters voted upon by the Joint Executive Committee. In case of a tie vote, the General Secretary-Treasurer shall cast the deciding vote.

ARTICLE X

Publications

Section 1. The name of the official journal of the Society shall be the "Journal of the American Society of Sugar Cane Technologists." This Journal shall be published at least once per calendar year. All articles, whether volunteered or invited, shall be subject to review as described in Section 4 of Article X.

Section 2. The Managing Editor of the Journal of the American Society of Sugar Cane

Technologists shall be a member of either the Florida or Louisiana Divisions; however, he or she shall not be a member of both Divisions. The Division affiliation of Managing Editors shall alternate between the Divisions from term to term with the normal term being three years, unless the Division responsible for nominating the new Managing Editor reports that it has no suitable candidate. The Managing Editor shall be appointed by the Joint Executive Committee no later than 6 months prior to the beginning of his or her term. A term will coincide with the date of the annual Joint Meeting of the Society. No one shall serve two consecutive terms unless there is no suitable candidate from either Division willing to replace the current Managing Editor. If the Managing Editor serves less than one year of his or her three-year term, another candidate is nominated by the same Division, approved by the other Division, and appointed by the General Secretary-Treasurer to a full three-year term. If the appointed Managing Editor serves more than one year but less than the full three-year term, the Technical Editor from the same Division will fill the unexpired term of the departed Managing Editor. In the event that the Technical Editor declines the nomination, the General Secretary-Treasurer will appoint a Managing Editor from the same Division to serve the unexpired term.

Section 3. The "Journal of the American Society of Sugar Cane Technologists" shall have two Technical Editors, which are an Agricultural Editor and a Manufacturing Editor. The Managing Editor shall appoint the Technical Editors for terms not to exceed his or her term of office. Any Technical Editor shall be a member of either the Louisiana or Florida Division. Each Division will be represented by one technical editor at all times unless the Executive Committee of one Division and the Managing Editor agree that there is no suitable candidate willing to serve from that Division.

Section 4. Any member or nonmember wishing to contribute to the Journal of the American Society of Sugar Cane Technologists shall submit his or her manuscript to the Managing Editor. The Managing Editor shall then assign the manuscript to the appropriate Technical Editor. The Technical Editor shall solicit peer reviews until, in the opinion of the Technical Editor, two responsible reviews have been obtained that either accept (with or without major or minor revision) or reject the manuscript. For articles accepted with major revision, it shall be the responsibility of the Technical Editor to decide if the authors have satisfactorily completed the major revision(s). The Technical Editor may solicit the opinion of the reviewers when making this decision. The Technical Editors shall not divulge the identity of any reviewer. The Managing Editor shall serve as Technical Editor of any manuscript which includes a Technical Editor as an author.

ARTICLE XI

Amendments

Section 1. Amendments to this Constitution may be made only at the annual meeting of the Society or at a special meeting of the Society. Written notices of such proposed amendments, accompanied by the signature of at least twenty (20) active or honorary members must be given to the General Secretary-Treasurer at least thirty (30) days before the date of the meeting, and he or she must notify each member of the proposed amendment before the date of the meeting.

ARTICLE XII

Dissolution

Section 1. All members must receive notification from the General Secretary-Treasurer of any meeting called for the purpose of terminating the Society at least thirty (30) days prior to the date of the meeting. After all members have been properly notified, this organization may be terminated at any time, at any regular or special meeting called for that purpose, by an affirmative vote of two-thirds of the total honorary and active members in good standing present at the meeting. Thereupon, the organization shall be dissolved by such legal proceedings as are provided by law. Upon dissolution of the Joint Society, its assets will be divided equally between the two Divisions of the Society. Dissolution of the Joint Society will not be cause for automatic dissolution of either Division. Upon dissolution of either Division, its assets will be divided in accordance with the wishes of its members and in conformity with existing IRS regulations and other laws applicable at the time of dissolution.

ARTICLE XIII

Assets

Section 1. No member shall have any vested right, interest or privilege of, in, or to the assets, functions, affairs or franchises of the organization; nor any right, interest or privilege which may be transferable or inheritable.

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Sugar Cane Technologists

Volume 18
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American Society of Sugar Cane Technologists
David M. Burner

Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to five living Honorary members assigned to the two Divisions jointly. (Article III, Section 4 of the Constitution of the American Society of Sugar Cane Technologists).

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David G. Hall. Seasonal Activity of Adult Lesser Cornstalk Borers (*Elasmopalpus lignosellus*) and Sugarcane Borers (*Diatraea saccharalis*) Based on Pheromone Trapping in Florida.

B. L. Legendre and E. P. Richard, Jr. Post-Harvest Management of Billeted Cane for Optimal Cane and Juice Quality.

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PRESIDENT'S MESSAGE
LOUISIANA DIVISION

Duane Legendre
Raceland Raw Sugar Corp.

From where have we come; to where are we going? These were the questions uppermost in the minds of those of us in the Louisiana sugarcane industry as we celebrated our 200th anniversary. In reflecting on the history of the Louisiana sugar industry, we realize we have made great strides in the production and processing of sugar since the time Etienne de Bore first learned to make sugar from the extracted juice of the sugarcane plant in Louisiana.

We have learned much about improved varieties of cane that are suited to various soil types and weather conditions and those varieties less susceptible to diseases and insects. Variety development has always been, and continues to be, a top priority for industry research efforts.

Research priorities have resulted in the development of higher yielding varieties. This was reflected in the state's industry records for 1996. Louisiana farmers produced an average yield of 31.3 tonnes of cane per acre, resulting in the production of 6,250 pounds of sugar per acre. This can be attributed to the rapid expansion in the use of sugarcane variety LCP 85-384. This currently is the highest yielding variety known to the Louisiana industry.

Increased use of this variety has also resulted in the introduction of the combine harvester in Louisiana. During 1996, approximately 15 percent of the state's tonnage was harvested by combine harvesters. It is anticipated that this will increase to over 35 percent of the crop in 1997. So, where do we go from here?

Mechanization research has been deemed vital to determine whether processors and/or producers should make changes to handle the alternative harvesting techniques. Various research projects are being conducted by Louisiana State University, by the Agricultural Research Service of the United States Department of Agriculture, and by the American Sugarcane League scientists to determine profitability of the combine system.

Leaders in the research area are also focusing their efforts on more effective production as well as harvesting techniques. Studies are underway to determine the feasibility of planting billeted cane which, if effective, could reduce planting cost dramatically.

With the introduction of combine harvesting of cane to Louisiana, both the grower and the processor are faced with the added expense of the transition to the newer combine harvesters. Further, with combine cane comes problems, both in the field and in the factory. Billeted cane deteriorates faster and hastens the formation of dextran. Intensive management is the key to preventing this problem. Further, the effects of repeated combine harvesting on stubbling is unknown as well as the effects of combine cane on processing.

Increased efficiency in other aspects of cane and sugar production continues to be emphasized. Industry support of biotechnology research continues in an effort to improve productivity. The objective is for future varieties to increase overall industry productivity. Gene mapping is currently being undertaken through cooperative research with other sugar industries. Genetically engineered plants have been produced and are being tested in an effort to incorporate these technologies into the conventional breeding programs.

Leaders in the industry recognize that we are at important crossroads. Higher yields and increased efficiency are definitely necessary if we are to remain globally competitive. Not only the producers but the processors must continue to work to improve the efficiency of their operations.

All of the research projects that are being conducted require funding for their respective efforts. The sugar industry meets the challenge through the Dedicated Research Funding Program funded by the growers and processors of the state coordinated by the American Sugarcane League and the Louisiana Farm Bureau.

During last year, as in past years, there were legislative attempts to destroy or dismantle the domestic sugar program. Louisiana sugar leaders again took an active role in bringing about the defeat of these attempts. It is Louisiana's intent to continue to work for the best interest of the domestic sugar program.

Industry personnel have also worked in areas of environmental concerns. They were particularly concerned with regulations and policies regarding open field burning of sugarcane, sugar mill air emissions, factory waste water discharge, and factory solid waste disposal.

There are those who may think the sugar industry is on the way out. Records from 1996 indicate otherwise. In fact, for the third consecutive year, Louisiana produced over one million tonnes of sugar.

Sugar recovery at the mills averaged above 10 percent for the 6th time in the past ten years.

Acreage for 1997 is expected to be an all-time high, probably near 400,000 acres, although harvested acreage was down in 1996 due largely to winter freezes.

For the first time since the turn of the century, sugar production will take place in the western portion of the state. It is anticipated that expansion in that area will exceed 100,000 acres by the year 2000.

On the manufacturing end, innovative ideas were and are being incorporated into several Louisiana sugar mills to improve their operations. This technology includes the installation of hydraulic mill drives, planetary gears for mill drivers, and the beginning of construction on a 10,000 tonne per day sugarcane diffuser.

Does this sound like a dying industry? I think not. The cooperative effort of all who work both in and for the sugar industry, or even those outside the industry, is what makes this industry viable. It is this continuing cooperative effort that allows the Louisiana sugar industry to continue to grow and compete in the global marketplace of the future.

PRESIDENT'S MESSAGE
FLORIDA DIVISION

Modesto F. Ulloa
Sugar Farms Coop.

Let me begin by thanking the Louisiana Division of the American Society of Sugar Cane Technologist for hosting the 27th Annual Joint Meeting in Fort Walton Beach, Florida.

In summary, my address will begin with a briefing on the production results from 1996-97 crop. In addition I will outline some events of importance to Florida producers, and what role I feel we need to establish in order to regain control of our future in the Everglades Agricultural Area (EAA). I will try to cover the events and contributions from the industry that in general were important in characterizing 1996.

From the field side, let me say that despite freezing weather experienced during the week of January 18th, the Florida sugar industry completed a successful crop on March 23rd. This season's mid January freeze was well managed, through both a harvesting strategy and cold tolerant varieties. The strength of United States Sugar Corporation (CL) and USDA (CP) varieties made it possible for us to finish the 1996-97 Crop without significant declines in juice quality. The campaign lasted a total of 153 days from the start of the first to the finish of the last mill, and yielded 1,679,179 short tons of 96 sugar. The average sugar recovery per gross ton of cane was 220.8 pounds versus 221.4 for last year. Per acre cane production was lower on the marginal mucks affected by the freezing weather in February of 1996, and in the mineral soils due to periods of prolonged drought last summer. Weather conditions during this harvest and planting season were nearly ideal, and the 1997-98 crop is off to very good start. Official acreage figures have not been audited yet so at this time I am unable to generate per acre production trends.

In the environmental and political arena, the State and Federal Political Agenda and the negative attitudes fueled by environmental advocates have set an unfavorable climate for a scientific problem solving method. The narrow margin of 54.5% that voted "NO" on Amendment 4 is indicative of an urban community that does not strongly sympathize with the Florida Sugar Producer. This political battle was won thanks to strategist that designed an uncomplicated campaign that voters could well relate to. The major emphasis of the message dealt with the loss of jobs, the inefficient use of tax dollars, the potential for additional taxation, and the recognition that the Florida sugar producers were making, and had made significant monetary contributions toward restoration of the environment. This brief and clear campaign together with the sacrifices and the support from all sugar related businesses and families in the area was enough to turn the vote in our favor. I thank you on behalf of the Executive Committee for your efforts.

This victory does not vaccinate us from future attacks. It does, however, buy us time to rally, and with educational and public awareness programs, help our urban neighbors clearly understand the value and environmental friendliness of the Florida Sugar Industry. Sugar production is an environmentally friendly cropping and manufacturing alternative, because of its suitability to the EAA. The principal cropping and harvesting operations are carried out during the fall and winter months. This period is typically dryer than the summer. Therefore we can say that sugarcane culture is in tune with the South Florida climate. In addition, industrial sugar production is energy efficient, and none of its processes involve the use of hazardous or environmentally undesirable materials. Our factories operate on renewable fuel and burn well within EPA air quality standards. We have a good story to share, and it is our responsibility, as sugar technologists, to make sure that it is well told, and understood.

Currently, the executive committee of this Florida society is discussing possible direct involvement in educational programs with high schools in the area. Members of the ASSCT Florida Division should volunteer to serve as friends and science project mentors to future generations in order to forge good and lasting relationships between the urban and agricultural sectors. In addition to our efforts, private sugar corporations are opening their doors to visitors and special interest groups for outsiders to see first hand, that qualified and well intentioned persons operate this industry in the best interest of South Florida. Other Florida private sugar businesses are launching a farming and environmental television campaign. These and other individual and joint efforts are what makes the difference. We will be here, and stronger, well into the 21st century, because our industry makes good sense to the economy and to the environment.

Farmers within the EAA contributed $12.8 million to the Agricultural Privilege Tax during the first year of the Everglades Forever Act (EFA). In addition, they sponsored approximately $ 3 million of research at the Everglades Protection District designated to improve water quality in Lake Okeechobee and the Everglades. All EAA farmers have implemented an array of farm Best Management Practices (BMP's), with associated water flow and phosphorous monitoring, at drainage pump locations. There was a 68% reduction of phosphorous for the EAA last year with a three year average of 47%, thus greatly exceeding the 25% regulatory requirement.

The construction of storm water treatment areas (STA's) by the South Florida Water Management District (SFWMD) are continuing on schedule despite poor fiscal planning and controls by the District. The SFWMD presented potential project short falls of as great as $180 million which upon further scrutiny by the Florida Legislature, were reduced to $29 million with much analysis still being needed. Another threat to constructing the STA's is the recent dredge and fill permit by U.S. Army Corps which does not agree with the EFA. However construction contracts are proceeding with STA #6 and "inflow works" to STA #1. Negotiations will continue regarding these issues.

Sugarcane and rice production are the closest alternative to sawgrass that make good environmental sense with respect to land use management and economic development for the State of Florida. Farming is the ideal transitional buffer that benefits both the urban and wildlife management sectors.

On the research and technology front, our breeders are feeling the pressure. Sugarcane in Florida has been exposed to a flurry of new diseases reducing the effectiveness of conventional breeding programs and eliminating major commercial cultivars from our production system. Most of our commercial cultivars are susceptible but tolerant enough to allow for a transitional period. Additional resources will be needed for the USDA Canal Point Program to regain lost ground quicker. Conventional breeding systems rely on increased seedling numbers, and this equates to increased cost. As a field person, I believe that a good variety development program is the essence of sugar production. Like my predecessors, I too have learned that sugar is made in the fields and not in the factory.

But the future is promising. As an alternative, and in order to compliment current breeding methods, we now must turn the page to biotechnology. I am sure all of you have heard of the Green Revolution. It was responsible for averting starvation in many parts of the developing world. We have now entered the Biotechnology Revolution and some molecular biology techniques are now being applied to sugarcane.

In 1988, the first steps were taken to determine the feasibility to map the sugarcane genome. It was soon learned that this type of basic research is indeed very costly. In July 1991, seven research institutes representing four countries (Australia, Brazil, United States, and South Africa) signed a memorandum of understanding (MOU) and established the International Consortium on Sugarcane Biotechnology (ICSB). Since then, new member countries have agreed to fund projects through the Consortium (Colombia, Mauritius, Argentina, Philippines, and Reunion). From the U.S., four institutions are members: American Sugar Cane League, Florida Sugar Cane League, Texas A&M, and U.S.D.A.

Let me, in a brief moment , tell you about the progress made and the future prospects in sugarcane biotechnology. First, the basic research funded through the ICSB since 1989 has reached about $3.2 million by the end of 1997. Florida has contributed about 5.5% of that total. Second, during this time period fourteen projects have been funded by contract with third parties. Third, the research funded has been primarily in two areas: (1) sugarcane genome analysis (e.g.., molecular mapping marker associated to traits of interest like disease resistance and high sucrose content, and map-based cloning), and (2) genetic transformation, or the creation of a new, genetically different individual without the use of sexual reproduction. Regarding this aspect of transformation, sugarcane has already been genetically transformed for herbicide resistance in Texas, Hawaii, Australia, and South Africa. Potential application for other desirable transformation, like disease resistance to sugarcane mosaic virus, are currently being worked on. Laboratory and greenhouse data from the above mentioned locations are encouraging, however transformed plants need to be approved for release to the commercial environment, evaluated under field conditions, and licensing must be completed with companies owning genes and possibly the transformation techniques. Even though promising to the industry, I feel, that earliest application of this work is still a few years away.

One final area of interest that I would like to mention is that of employee standards, conservation practices, health, and environmental restrictions that are imposed upon U.S. farmers. These regulations, under which we work, far exceed those of most imported sugars. Therefore, our cost is higher. For example, Monsanto tested a new compound (SEMPRA) for control of a specific weed called nutsedge in Florida years ago. Nutsedge has become a uncontrollable nuisance for Florida sugarcane farmers but SEMPRA has not yet been registered for use in Florida sugarcane fields. Last year, while in Colombia and Brazil I found this same herbicide under the trade name SEMPRA in full commercial use. This is only one example of many that highlighted differences between U.S. and foreign producers. This difference in imposed standards has not been taken into consideration by supporters of so-called free trade. The field is not level based on the political , social, or scientific standards. In spite of the above the U.S. farmer/producer is still among the most competitive.

Sugar has not increased in price over the years and this has made us more innovative. We have crossed over from an industry fueled by offshore labor, with runaway costs, many liabilities, and much negative publicity, to 100% mechanization. This transition was accomplished in 5 years. The industry has looked for added value through the expansion of sugar refining capacity, cogeneration, specialty sugars, and rotation crops. Engineers are actively working to implement new techniques to increase recovery in the sugarhouse, and plant breeders have increased cane production trends through added disease resistance, cold tolerance, and increased juice quality. However there is still much to be learned. Developments in both agriculture and manufacturing in such countries as Australia, Brazil, South Africa, and others, must be reviewed and studied for potential implementation in mainland United States. The challenge is still there, let us pursue it.

PEER

REFEREED

JOURNAL

ARTICLES

AGRICULTURAL

SECTION

ESTIMATES OF HERITABILITY IN A BACKCROSS POPULATION OF INTERSPECIFIC AND INTERGENERIC HYBRIDS IN SUGARCANE

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ABSTRACT

Saccharum spontaneum, *Erianthus* spp., and *Miscanthus* spp. have been used through interspecific and intergeneric hybridization to transfer their desired characters into cultivated sugarcane. However, genetic information needs to be established so that breeders can effectively use those characters in their breeding programs. The BC_2 populations produced by mating four BC_1 hybrids (one interspecific and three intergeneric) to three commercial cultivars as males were used to determine the relative effect of parents on morphological characters (stalk height, number, diameter and weight) and juice quality (Brix, sucrose content and purity). The results showed that the female effects were significant for all characters examined, but only the measurements of the juice quality showed significant male effect and male x female interaction. Genetic information obtained from this study should assist in establishing backcross and selection strategies for a sugarcane breeding program utilizing basic germplasm.

INTRODUCTION

The genus *Saccharum* consists of six species, *S. officinarum* L. (noble cane), *S. spontaneum* L., *S. barberi* Jesw., *S. sinense* Roxb., *S. robustum* Brandes and Jeswiet ex. Grassl, and *S. edule* Hassk. (Brandes, 1958). The genus *Saccharum* and its related genera including *Erianthus*, *Miscanthus*, *Sclerostachya*, and *Narenga* together have been called the *Saccharum* complex (Daniels and Roach, 1987). The high polyploidy in *Saccharum* helps overcome obstacles to hybridization with other genera within the complex (Janaki Ammal, 1941). Sugarcane and related grasses have been actively used in the basic breeding program at Canal Point, Florida (Grassl, 1963; Tai and Miller, 1988; Tai et al., 1991 and 1992). Reasons for using *S. spontaneum* and related genera in sugarcane breeding include expansion of the germplasm base of commercial sugarcane and breeding clones, the transfer of desired characteristics that do not exist to a satisfactory degree in *Saccharum*, and the heterotic effect for yield and sugar content (Grassl, 1963; Roach, 1984; Tai and Miller, 1988). Estimates of broad-sense heritability for morphological and juice-quality characters in biparental crosses between commercial cultivars have been obtained (Brown et al., 1968; Hogarth, 1971 and 1977; Hogarth et al., 1981; Kang et al., 1983). Heritability estimates in progeny derived from interspecific and intergeneric crosses between *S. officinarum* and *S. spontaneum,* between commercial cultivars and *S. spontaneum*, and between commercial cultivars and *Miscanthus* and/or *Erianthus* have been reported (Roach, 1969; Tai et al., 1991 and 1992). Based on the performance of progeny, Jackson and Roach (1994) suggested that little or no immediate gain from heterosis may be achieved by crossing F_1 clones derived from diverse *S. spontaneum* sources. In order to more effectively use interspecific and intergeneric hybridizations to broaden the genetic base in sugarcane, information on the genetic behavior of characters of economic importance needs to be established. The objective of this study was to estimate the heritability of some morphological and juice-quality characters in a backcross population of interspecific and intergeneric hybrids in sugarcane.

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MATERIALS AND METHODS

During the 1990/91 flowering season, four BC_1 clones (US 88-1014, US 90-1025, US 90-1027 and US 90-1028) derived from backcrosses of interspecific and intergeneric hybrids (Fig. 1) (Tai and Miller, 1988; Tai et al., 1991 and 1992) were used as female parents to produce BC_2 seed by crossing them to each of three commercial cultivars, CP 70-1133, CP 81-1135 and CP 81-1425. The BC_2 seedlings were transplanted to field plots in a randomized complete block design in five replications in June 1991. Both BC_1 and BC_2 were defined as the first and second backcrosses of the interspecific or intergeneric hybrids to commercial cultivars, respectively. Approximately 120 seedlings from each of the BC_2 families were planted in a two-row plot at 0.3 m intervals with 1.5 m between plots and rows. Data on stalk height (m), stalk number, and stalk diameter (mm) from 40 plants were selected at random from each plot in December 1991. Stalk height was measured from the base to the top visible dewlap, and stalk diameter was measured on five mature stalks per plant, at mid-internode, approximately 0.5 m above the ground. Stalk number was the number of mature stalks per seedling. All mature stalks were cut for determining stalk weight and milled for juice analysis in January 1992. Determination of percent sucrose was by polarimetry. Percent purity was calculated from the ratio of percent sucrose to Brix. Crossing, field evaluations and laboratory analyses were conducted at the USDA-ARS Sugarcane Field Station, Canal Point, Florida.

Analyses of variances were carried out for each of the characters examined using individual plant and plot mean data (Becker, 1985; Hogarth, 1971; Steel and Torrie, 1980). Duncan's Multiple Range Test (Steel and Torrie, 1980) was used to compare means of all characters among BC_2 populations. Variance components attributed to males(σ_m^2), females (σ_f^2), and male x female interaction (σ_{mf}^2) were estimated. Estimates of additive genetic variance (σ_A^2) were calculated as 4 σ_m^2 and estimates of dominance genetic variance (σ_D^2) were calculated as 4 σ_{mf}^2.

Narrow-sense heritability (h^2) was estimated by three ways (Becker, 1985; Falconer, 1967):

$$h_m^2 = 4\sigma_m^2 / \sigma_P^2$$
$$h_f^2 = 4\sigma_f^2 / \sigma_P^2$$
$$h_{m+f}^2 = 2(\sigma_m^2 + \sigma_f^2)/\sigma_P^2$$

Where σ_P^2 (individual plant basis) was the total variance ($\sigma_P^2 = \sigma_m^2 + \sigma_f^2 + \sigma_{mf}^2 + \sigma_w^2$), and σ_w^2 was the variance component of within family or plant to plant within a plot.

RESULTS AND DISCUSSION

The means for all characters varied significantly among BC_2 populations (Table 1). However, there was no notable trend of showing high or low means produced by specific male or female parent or by a group of backcrosses.

An analysis of variance indicated that the female effect was significant for all characters examined, but only stalk height, Brix, percent sucrose and percent purity showed significant male and male x female interaction effects (Table 2). Variance components show that σ_f^2 was greater than σ_m^2 for all characters except percent purity (Table 2). The σ_f^2 component contains additive genetic variance plus variances of dominance and common environment (Falconer, 1967). The differences between female parents (interspecific and intergeneric hybrids) were greater than the differences between male parents (commercial cultivars). The interaction variance components between male and female parents were small for most characters examined. Estimates of the variance components for juice-quality characters of this study ($\sigma_m^2 < \sigma_f^2$) differed from those of BC_1 progeny derived from backcrosses between commercial sugarcane and *S. spontaneum* ($\sigma_m^2 > \sigma_f^2$) (Tai et al., 1992). The difference could be due to materials with which genetic variances were estimated. The materials used for the present study were derived from both intergeneric and interspecific hybrids of three genera, *Erianthus, Saccharum, and Sclerostachya*, while the materials used by Tai et al. (1992) were derived from interspecific hybrids of *Saccharum*. This difference in a genetic variance might warrant further investigation. Among genetic variances, additive genetic variance (σ_A^2) was greater and more important than dominance genetic variance (σ_D^2) for stalk diameter, stalk weight, sucrose, and purity. Therefore, the average performance of progeny for these four characters would be determined by the mean performance of parental clones. The ratios of non-additive to additive genetic variance (σ_D^2:σ_A^2) showed that there was little or no dominance for genes controlling these four characters. There was some degree of overdominance for genes controlling stalk height, stalk number, and Brix. Information on the genetic manipulation on these quantitative characters should be useful to the selection practice in backcross progeny.

The estimates of heritability varied considerably between estimating methods and between characters (Table 3). Based on estimation from variance components, three estimates (h_m^2, h_f^2 and

h_{m+f}^2) showed the heritability of stalk weight was very low and the heritability of percent sucrose was moderate. Heritability of other characters varied among methods. Female genetic variance, σ_f^2, tended to give higher estimates for nearly all characters than did the other two estimates, σ_m^2 and σ_{mf}^2. The female variance component was greater than the male variance component and was inflated by non-additive (dominance variance) and common environment effects. Therefore, the two estimates of the heritability, h_f^2 and h_{m+f}^2, from the female component and male-female combination may be

biased upward. The estimate of the heritability from male variance components would be more reliable than that from female variance component.

The present heritability analysis was based on the variability associated with individual plants. This information should be useful to sugarcane breeders who practice seedling selection on an individual plant basis. The heritability of both Brix and percent sucrose was fairly consistent and of a moderate magnitude, but the estimates of heritability for the other five characters varied widely. Selection of clones for high sugar content within the BC_2 population of the interspecific and intergeneric hybrids of sugarcane would be more successful than selection of clones for other characters examined. Genetic gain from selection for stalk weight, stalk height, stalk number, stalk diameter, or percent purity in BC_2 population of interspecific and intergeneric hybrids would be uncertain.

Our information on a genetic variance, degree of dominance, and heritability of morphological and juice-quality characters obtained from a backcross population of interspecific and intergeneric hybrids should assist us in establishing more effective backcross and selection strategies for the breeding program. This study involved a limited number of parents and backcrosses. Further investigations on variation in heritability from one population to another involving more parents and backcrosses could provide us with additional knowledge about genetic gains through the procedure of nobilization. Increased replications and family selection for some characters with low heritability would improve our progress. Elite clones with superior performance in some of the important characters should be used as parents in backcrosses. This information also should increase germplasm utilization of wild sugarcane and related genera by using clones with superior agronomic characters for hybridization.

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Table 1. Means of morphologic and juice-quality characteristics of the progeny derived from backcrosses of interspecific and intergeneric hybrids of sugarcane.

Cross	Stalk height	Stalk number	Stalk diameter	Stalk weight
	m	#	mm	Kg
US88-1014 x CP70-1133	2.28 a*	3.3 def	21.87 ab	1.08 ab
US88-1014 X CP81-1135	2.11 bc	3.7 def	22.76 a	1.28 a
US88-1014 X CP81-1425	2.02 cd	4.2 abc	22.82 a	1.32 a
US90-1025 X CP70-1133	1.83 e	3.9 bcd	20.48 cde	1.05 ab
US90-1025 X CP81-1135	1.93 de	4.7 a	21.26 bc	1.08 ab
US90-1025 X CP81-1425	1.92 de	4.5 ab	20.41 cde	1.18 ab
US90-1027 X CP70-1133	2.20 ab	3.7 cde	19.58 e	0.98 bc
US90-1027 X CP81-1135	2.10 bc	3.4 def	19.91 ed	1.08 ab
US90-1027 X CP81-1425	1.93 de	3.3 ef	19.42 e	0.82 d
US90-1028 X CP70-1133	2.12 bc	2.8 f	20.86 bcd	0.82 d
US90-1028 X CP81-1135	1.92 de	2.8 f	21.16 bc	0.99 bc
US90-1028 X CP81-1425	1.98 cde	3.2 ef	21.78 ab	0.83 d
Grand mean	2.24	3.7	20.97	0.96

Cross	Brix	Sucrose	Purity
		%	
US88-1014 X CP70-1133	13.82 ab	9.89 bc	71.28 a
US88-1014 X CP81-1135	13.77 ab	9.54 bc	68.64 abc
US88-1014 X CP81-1425	14.13 a	10.10 ab	71.00 ab
US90-1025 X CP70-1133	11.96 c	8.19 d	67.38 bc
US90-1025 X CP81-1135	12.15 bc	8.19 d	66.91 bc
US90-1025 X CP81-1425	12.75 bc	8.48 cd	65.91 bc
US90-1027 X CP70-1133	11.58 c	10.09 ab	67.46 bc
US90-1027 X CP81-1135	12.96 bc	8.73 c	72.77 a
US90-1027 X CP81-1425	13.77 ab	10.07 ab	73.13 a
US90-1028 X CP70-1133	14.23 a	10.31 a	72.51 a
US90-1028 X CP81-1135	12.81 bc	8.08 d	62.99 d
US90-1028 X CP81-1425	14.05 a	10.05 ab	70.86 ab
Grand mean	13.16	9.31	69.24

* Means followed by the same letter(s) are not significantly different at the 0.05 probability level using Duncan's Multiple Range Test.

Table 2. Estimates of variance components and genetic variance of selected traits in BC_2 population of interspecific and intergeneric hybrids of sugarcane.

	Variance Component†				Genetic Variance‡		
Character	σ_m^2	σ_f^2	σ_{mf}^2	σ_w^2	σ_A^2	σ_D^2	D/A
Stalk height	0.001*	0.008**	0.007*	0.094	0.004	0.028	7.00
Stalk diameter	0.190	1.095**	-0.243	8.001	0.760	-0.972	0
Stalk weight	0.008	0.072**	-0.028	1.359	0.016	-0.112	0
Stalk number	-0.256	0.289**	0.030	2.819	0	0.120	-
Brix	0.117**	0.489**	0.129*	2.197	0.468	0.516	1.10
Sucrose (%)	0.273**	0.395**	0.153*	3.341	1.092	0.612	0.56
Purity (%)	3.829**	0.880**	2.340**	68.801	15.316	9.360	0.61

*, ** Significant F values for the corresponding mean squares at 0.05 and 0.01 probability levels, respectively.

† Variance components: σ_m^2 = males, σ_f^2 = females, σ_{mf}^2 = female x male interaction, and σ_w^2 = individual plants.

‡ Genetic variance: σ_A^2 = additive, σ_D^2 = dominance, and D/A = σ_D^2:σ_A^2 ratio.

Table 3. Estimates of heritability of morphological and juice-quality characters in BC_2 population of interspecific and intergeneric hybrids of sugarcane.

Character	Estimated heritability based on variance components[†]		
	h_m^2	h_f^2	h_{m+f}^2
Stalk diameter	0.075 ± 0.093	0.430 ± 0.120	0.252 ± 0.108
Stalk height	0.052 ± 1.248	0.290 ± 2.072	0.171 ± 2.510
Stalk weight	0.017 ± 0.223	0.150 ± 0.337	0.084 ± 0.366
Stalk number	0	0.316 ± 0.349	0.158 ± 0.309
Brix	0.151 ± 0.062	0.634 ± 0.518	0.393 ± 0.347
Percent sucrose	0.245 ± 0.276	0.356 ± 0.343	0.300 ± 0.347
Percent purity	0.184 ± 0.005	0.042 ± 0.047	0.113 ± 0.080

[†] h_m^2 = estimate based on male component; h_f^2 = estimates based on female component; and h_{m+f}^2 = estimates based on male and female components.

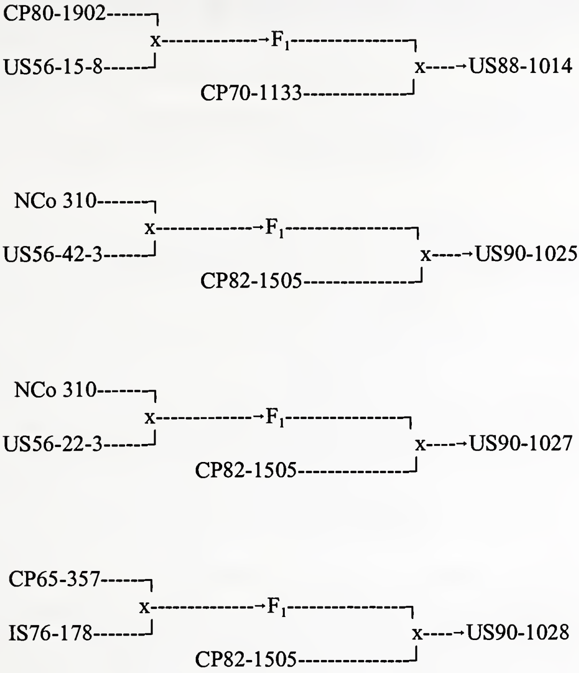

Fig.1. Pedigrees of four female parents in a backcross population. US56-15-8 is a *Saccharum spontaneum* clone, US56-42-3 is a *Miscanthidium sorghum* clone, US56-22-3 is a *Miscanthus floridulus* clone, and IS76-178 is an *Erianthus arundinaceus* clone. Sugarcane cultivars:CP65-357, CP70-1133, CP80-1902, CP80-1505, and NCo 310.

BERMUDAGRASS (*Cynodon dactylon*) AND JOHNSONGRASS (*Sorghum halepense*) CONTROL PROGRAMS IN SUCCESSION-PLANTED SUGARCANE (*Saccharum* spp. hybrids)

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ABSTRACT

Sulfometuron applied preemergence (PRE) to succession-planted sugarcane controlled johnsongrass (79 to 93%) and reduced bermudagrass ground cover in the plant-cane crop when compared to metribuzin at standard rates. In three of four experiments, sulfometuron applied PRE after planting and, in the case of the bermudagrass study reapplied the following March, did not adversely affect crop emergence or early-season growth. When followed by a postemergence (POST) asulam application, johnsongrass panicle counts at the end of the plant-cane growing season were reduced 30% more where sulfometuron was applied at-planting compared to metribuzin. When PRE applications of sulfometuron were followed by asulam POST to control johnsongrass, plant-cane stalk counts and gross cane and sugar yields were at least 8% greater than the metribuzin followed by asulam treatment in the 1994-1995 experiment. A similar response was not obtained in the 1993-1994 experiment due to early-season crop injury from sulfometuron. In a separate study, gross cane yields were increased in the 1993-1994 experiment following at-planting and spring applications of metribuzin (15%) or sulfometuron (24%) to control bermudagrass when compared to the weedy check. Increases in bermudagrass control following treatment with sulfometuron were not reflected as further increases in sugar yields when compared to the metribuzin treatment. In the 1994-1995 experiment where low bermudagrass infestation levels did not negatively impact the crop, gross cane and sugar yields following treatment with sulfometuron were similar to the weedy check but at least 8% lower than the metribuzin standard. **Nomenclature:** Asulam, methyl[(4-aminophenyl)sulfonyl] carbamate; metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-

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triazin-5(4*H*)-one; sulfometuron, 2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]carbonyl] amino]sulfonyl]benzoic acid; bermudagrass, *Cynodon dactylon* (L.) Pers.; johnsongrass, *Sorghum halepense* (L.) Pers.; sugarcane, a complex hybrid of *Saccharum* spp. CP 72-370 and LCP 82-89.

Key words: Asulam, crop injury, perennial weeds.

INTRODUCTION

In Louisiana, a plant-cane (first year) and two ratoon (second and third year) crops can be harvested following the planting of sugarcane stalks in August and September. Each crop occupies approximately one fourth of a producer's land with the remaining portion being fallowed in preparation for planting. During the 3-yr crop cycle, the row top remains undisturbed creating conditions which are conducive to the development of bermudagrass and johnsongrass. Bermudagrass biomass can increase 340 and 490% between the plant-cane and first-ratoon crop and first- and second-ratoon crops, respectively, with yield reductions of 10 to 17% per year (Richard 1993). Johnsongrass biomass can double between the plant-cane and first-ratoon crop with full-season johnsongrass interference in a first-ratoon crop reducing cane yields 86% compared with a 42% reduction in a plant-cane crop (Millhollon 1995). No herbicides are labeled for the selective POST control of bermudagrass in sugarcane (Richard 1992, 1996). Asulam applied POST can reduce the economic impact of johnsongrass by providing temporary control (Bruff et al. 1996, Richard 1990).

Fields are typically fallowed after the third harvest because increasing infestations of bermudagrass and johnsongrass, as well as diseases, make the profitability of a fourth harvest questionable (Faw 1995). The fallow period begins after harvest with the destruction of the sugarcane stubble by tillage and/or application of glyphosate [*N*-(phosphonomethyl)glycine]. Timely tillage (disking and plowing) and/or glyphosate applied POST during the fallow period also promotes the depletion of seeds, rhizomes, and stolons of perennial weeds (Richard 1997a, 1997b). At-planting and spring applications of metribuzin can control seedling bermudagrass, johnsongrass, and other weeds within the sugarcane crop, but not plants emerging from rhizomes and stolons (Sanders 1995). Hence, the effectiveness of a fallow weed control program directly impacts weed pressure in the plant-cane crop and the continued harvests of ratoon crops. Fallowing is costly when considering the time and money spent for weed control on land not providing a marketable crop.

In some instances, sugarcane is replanted immediately following the harvest of the second-ratoon crop without a fallow period. Although good in theory, this practice, known as succession planting, has several drawbacks. Whereas traditional planting occurs in August and September, succession planting occurs in late October and November, which translates into a shorter establishment period before winter frost. Succession planting also requires coordination of harvesting and planting operations during the same time period. The elimination of a fallow period also enhances the risk that a producer will begin a crop cycle with heavy perennial weed pressures (Faw 1995).

Despite these drawbacks, such alternative programs may aid in increasing producer profits. With a standard rotation system, 85% of gross income is absorbed by costs (Johnson et al. 1993). This compares with only 79% when succession planting is employed on 60% of the acreage slated for fallowing in the subsequent year. Where weeds are not a limiting factor and an at-planting fertilizer application is used, succession planted sugarcane can produce total crop cycle yields comparable to those obtained through conventional planting following a summer fallow period (Ricaud and Arceneaux 1988).

Sulfometuron applied to fallowed sugarcane fields can control seedling and rhizomatous weeds including johnsongrass and provide temporary control of bermudagrass (Richard 1997a, 1997b). Application of sulfometuron to sugarcane at planting PRE and again in the spring of the plant-cane growing season early POST at a reduced rate can provide selective control of rhizome johnsongrass (Richard 1998). A reduced rate of sulfometuron is needed in the spring because the potential for crop injury is greater following a POST application (Richard 1998).

Sugarcane injury potential following at-planting applications of sulfometuron may also be greater where sugarcane is succession-planted because the shorter fall growth period associated with the later planting date also shortens the interval for crop recovery from herbicide injury. These studies were conducted to compare the use of sulfometuron and metribuzin programs for the control of perennated bermudagrass and johnsongrass in succession planted sugarcane and to determine the subsequent effect on sugarcane growth and yield.

MATERIALS AND METHODS

Johnsongrass Study

Experiments were initiated in 1993 and 1994 on adjacent sites at the St. Gabriel Research Station in St. Gabriel, LA on a Commerce silt loam soil (fine-silty, mixed, nonacid, thermic Aeric Fluvaquent) pH 7.6. Following mid-October harvests of first-ratoon (1993) and second-ratoon (1994) crops, 5 cm of the row top was removed with a hydraulically driven revolving disk shaver. The rows were opened, rotary tilled, closed, and re-opened to insure destruction of the previous crop's stubble pieces and to create a planting furrow into which CP 72-370 sugarcane stalks were placed and covered with 8-cm of packed soil.

Treatments included at-planting PRE applications of metribuzin at 2,020 g ai/ha and sulfometuron at 53, 105, or 158 g ai/ha followed by a POST application of asulam at 3,740 g ai/ha during the plant-cane growing seasons of 1994 and 1995. Asulam applications were made in April (metribuzin) or May (sulfometuron) when johnsongrass was 75 to 130 cm tall with 75 to 85% panicle emergence and sugarcane was 45 to 95 cm tall. Johnsongrass height was measured from the soil surface to the tip of the longest leaf, and sugarcane height was measured from the soil surface to the collar of the youngest leaf below the whorl. At-planting treatments were broadcast with a tractor-mounted compressed air-pressurized sprayer delivering 140 L/ha. Asulam was applied to a

90-cm band using a CO_2-pressurized backpack sprayer delivering a broadcast aqueous carrier volume of 140 L/ha. Crop oil concentrate[2] at 1% (v/v) was applied with asulam.

Sugarcane responses to at-planting treatments were determined by counting the number of shoots in each plot in early January. Johnsongrass control (reductions in height and infestation levels) was visually rated in the spring of the plant-cane growing season prior to asulam application. Visual estimates of johnsongrass control were compared with nontreated areas within the field and based on a percentage scale of 0 to 100 with 100% representing no plants present. As another estimate of johnsongrass control, and to assess benefits of asulam application, johnsongrass panicles/plot were determined in late August of the plant-cane growing season.

Bermudagrass Control

Experiments were initiated in 1993 and 1994 on adjacent sites on a Mhoon silty clay loam soil (fine-silty, mixed, nonacid, thermic Typic Fluvaquent) with a pH of 6.2 at the USDA Ardoyne Farm in Houma, LA. Rows were prepared for planting LCP 82-89 sugarcane immediately after mid-October harvests of second-ratoon (1993) and first-ratoon (1994) fields.

At-planting PRE herbicide treatments included metribuzin at 2,580 g/ha and sulfometuron at 56 or 112 g/ha. A weedy check was also included for comparison. Atrazine [6-chloro-*N*-ethyl-*N*'-(1-methylethyl)-1,3,5-triazine-2,4-diamine] at 2,240 g ai/ha was applied to the weedy check to limit interspecific weed competition. Herbicides were reapplied in late March at equivalent rates, except sulfometuron, which was applied at a reduced rate of 22 g/ha. All sulfometuron treatments were applied as mixtures with atrazine at 2,240 g/ha to insure control of broadleaf weeds. At-planting and March herbicide treatments were applied to a 90-cm band in a broadcast aqueous carrier volume of 190 L/ha using a tractor-mounted, compressed air-pressurized sprayer. At the time of the March applications, sugarcane was 9 cm tall and bermudagrass was dormant.

Bermudagrass control, based on visual estimates of the percentage of the soil surface covered with bermudagrass (0% = no cover and 100% = complete cover), was determined in mid-December (6 wk after planting) and again in late-May of the plant-cane growing season. Counts (number/plot) and height measurements (12/plot) of sugarcane shoots were also determined in mid-December as described previously.

Procedures Common to Both Studies

Fields were planted within 2 wk of the October harvest and subjected to conventional cultivation and fertilization practices. Plant-cane stalk counts (number/plot) and height measurements (12/plot) were made in late August. Plant-cane crops were mechanically-harvested in late November or early December of 1994 or 1995. Leaf material was removed from piles of harvested stalks by burning prior to weighing stalks to determine gross cane yield. A sample consisting of 15 harvested stalks, selected at random, was removed from each plot, weighed, and then crushed in a three-roller mill. Theoretically recoverable sugar (TRS) content of the extracted juice and sugar yields were determined using standard methodology.

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[2] Agri-Dex®, nonionic spray adjuvant is a crop oil concentrate that contains 83% heavy range, paraffinic petroleum hydrocarbons and 17% surfactant emulsifers (polyoxyethylene sorbitan fatty acid esters). Manufactured by Helena Chemical Co., Suite 500, 6075 Poplar Avenue, Memphis, Tenn. 38137.

Treatments were arranged in a randomized complete block design and replicated five (johnsongrass) or six (bermudagrass) times. Experimental plots consisted of three adjacent, 1.8 m wide rows 12.2 m (johnsongrass) or 10.7 m (bermudagrass) in length. Data in each study were subjected to analyses of variance within and across experiments (years) to determine significant interactions. Where interactions did not occur, data were combined. Where interactions occurred, data are presented for each experiment. Means of appropriate main effects and interactions were separated using Fisher's Protected LSD tests at $P = 0.05$.

RESULTS AND DISCUSSION

Johnsongrass Study

Metribuzin is relatively nonphytotoxic to sugarcane in Louisiana (Richard 1989). In the 1993-1994 experiment, sugarcane shoot numbers approximately 10 wk after planting were reduced 33, 58, and 68% following application of sulfometuron at 53, 105 or 158 g/ha, respectively, when compared with metribuzin (Table 1). In the 1994-1995 experiment, crop emergence was not affected by the at-planting applications of sulfometuron.

The difference in crop response between years can be explained by rainfall patterns and herbicide solubility. In 1993, above average (30 cm) rainfall fell during the 10-wk period after planting (12 cm within 15 d of treatment) compared with only 12 cm during the 10-wk period after planting in 1994. Sulfometuron, with a pKa of 5.2, becomes ionized at pH levels above this value thereby increasing water solubility (Harvey et al. 1985). Soil pH of 7.6, in combination with unusually high rainfall immediately after planting in 1993, may have resulted in leaching of the herbicide into the sugarcane root zone. The sugarcane cultivar CP 72-370 has greater susceptibility than other cultivars currently grown in Louisiana to several PRE herbicides (Millhollon and Koike 1986; Richard 1989), and the planting of a herbicide-sensitive cultivar may have also exacerbated injury potential under these conditions.

Where metribuzin was applied at planting, johnsongrass reached the designated growth stage for asulam treatment in the plant-cane crop in late-April each year. Similar growth stages were not reached until late-May when sulfometuron was applied. Sulfometuron at all rates provided commercially acceptable (79 to 93%) johnsongrass control in late May when compared to the 37% observed 4 wk earlier with at-planting metribuzin (Table 1). Johnsongrass control with sulfometuron was primarily associated with a reduction in johnsongrass height and stand. Despite some regrowth, johnsongrass panicle number was 30 to 43% lower late in the growing season when sulfometuron was followed by asulam than when metribuzin was followed by asulam (Table 1).

A significant year by treatment interaction was observed for sugarcane stalk counts in August. In the 1993-1994 experiment, sugarcane stalk numbers were equivalent for all sulfometuron and metribuzin treatments despite the injury observed earlier in the season (Table 2). In the 1994-1995 experiment, sugarcane stalk numbers for sulfometuron were similar regardless of rate and greater than for metribuzin. In another study where sugarcane was planted earlier into fields which were fallowed over the spring and summer months but heavily infested with rhizome johnsongrass, stalk numbers were higher when sugarcane was treated at-planting with sulfometuron than when treated with metribuzin (Richard 1998).

Sugarcane stalk height, stalk weight, and TRS levels did not differ for the various treatments both years (data not presented). As expected, gross cane and sugar yields in the 1993-1994 experiment were similar for the various treatments (Table 2). In the 1994-1995 experiment, gross cane and sugar yields were equivalent following the sulfometuron/asulam treatments. The sulfometuron followed by asulam treatments controlled johnsongrass sufficiently to produce cane yields greater than the metribuzin followed by asulam treatment. Of the sulfometuron treatments, only the at-planting application at 53 g/ha produced greater sugar yields than the standard metribuzin treatment, suggesting that higher rates of sulfometuron PRE applied late in the fall may be phytotoxic to succession-planted sugarcane on light-textured, high pH soils.

Bermudagrass Study

Sugarcane shoot populations in the fall were not affected by the various herbicide treatments 6 wk after planting in both experiments (Table 3). Bermudagrass development in the cool growth period in the fall after succession planting was slow as evidenced by the small amount (13%) of ground cover in the weedy check (Table 3). Nonetheless, sulfometuron did suppress bermudagrass cover relative to metribuzin. Bermudagrass cover in May of 1994 was much higher (88%) for the weedy check (Table 3). Lowest bermudagrass cover was observed following at-planting applications of sulfometuron at 112 g/ha. In May of 1995, bermudagrass covered only 26% of the row top in the weedy check. Differences between the treatments were not detected in 1995 as a result of slow bermudagrass development. The higher bermudagrass levels observed in 1994 were due to higher initial infestation from the preceding crop and to the fact that a more favorable growing season in 1995 resulted in higher sugarcane stalk populations and gross cane and sugar yields.

Although differences in bermudagrass control were noted in the fall following at-planting treatments and in the spring of 1994, they were not manifested as higher stalk populations (data not presented). Higher levels of bermudagrass in the weedy check (Table 3) caused a slight reduction in stalk height when compared with the other treatments in the 1993-1994 experiment (Table 4). In the 1994-1995 experiment, stalk height was reduced where sulfometuron was applied at 112 g/ha at planting and again in the spring at 22 g/ha. Differences in stalk height were reflected as reductions in stalk weight in the 1993-1994 experiment but not in the 1994-1995 experiment (data not presented). Differences in TRS levels between the various treatments were not detected in either experiment.

Metribuzin can temporarily suppress the development of bermudagrass within the sugarcane crop when applied in the spring (Richard 1993). Gross cane yields were 15% higher and sugar yields were 17% higher than the weedy check where metribuzin was applied at planting and again in the spring in the 1993-1994 experiment (Table 4). Sulfometuron controlled bermudagrass to a greater extent than metribuzin (Table 3). Hence, gross cane yields were at least 9% higher than the metribuzin treatment and 24% higher than the weedy check (Table 4). Sugar yields following treatment with sulfometuron to control bermudagrass were greater (25%) than the weedy check but similar to the metribuzin treatment. In the 1994-1995 experiment, the lower bermudagrass infestation did not negatively impact the crop. With one exception, both gross cane and sugar yields in the 1994-1995 experiment were higher for metribuzin than for sulfometuron. Reduced yield following sulfometuron in the 1994-1995 experiment may be attributable to crop injury which was detected in the stalk height measurements (Table 4).

In these studies, neither perenniated bermudagrass nor johnsongrass was completely eliminated by the weed control programs implemented. However, infestation levels of both weeds were generally reduced following at-planting applications of sulfometuron. As has been demonstrated in sugarcane planted after a conventional spring/summer fallow period (Richard 1998), where the presence of vegetative propagules of perennial weeds is anticipated in succession-planted sugarcane, use of sulfometuron at planting would lessen the economic impact of these weeds on the plant-cane crop and insure the competitiveness of the subsequent crops as weed infestation levels increase. Knowledge of soil pH and the potential for injury to succession-planted sugarcane following at-planting applications of sulfometuron at rates in excess of 56 g/ha would be critical to the success of this program, however.

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Table 1. Sugarcane shoot counts, johnsongrass control, and panicle counts after at-planting PRE applications of sulfometuron and metribuzin to succession-planted sugarcane.

		Sugarcane shoots[a]		Johnsongrass[b]	
Herbicide	Rate	93/94	94/95	Control	Panicles
	g/ha	no./ha	no./ha	%	no./ha
Sulfometuron	53	10,500	8,500	79	8,600
Sulfometuron	105	6,600	6,700	87	9,500
Sulfometuron	158	5,000	8,600	93	10,600
Metribuzin	2020	15,600	8,500	37	15,100
LSD (0.05)		1,400	NS	11	3,600

[a] Sugarcane shoot counts were made in January of the plant-cane growing season 10 wk after planting in 1993 and 1994.

[b] Johnsongrass control estimates were made prior to asulam applications in April (metribuzin) and May (sulfometuron) while panicle counts were made in August. Data are pooled over experiments.

Table 2. Sugarcane stalk counts and gross cane and sugar yields after sulfometuron and metribuzin at-planting PRE followed by POST asulam applications to succession-planted sugarcane[a].

		Stalks[b]		Cane		Sugar	
Herbicide	Rate	93/94	94/95	93/94	94/95	93/94	94/95
	g/ha	no./ha		kg/ha			
Sulfometuron	53	41,600	67,900	17,500	30,900	5,500	9,600
Sulfometuron	105	37,100	64,500	16,300	29,100	5,300	8,800
Sulfometuron	158	34,900	72,500	16,300	30,000	5,000	8,900
Metribuzin	2020	38,500	54,300	16,300	26,300	5,400	8,100
LSD (0.05)		NS	9,200	NS	2,700	NS	1,100

[a] Asulam at 3,740 g/ha was applied to metribuzin treatments in April and to sulfometuron treatments in May.

[b] Sugarcane stalks were counted in August of the plant-cane growing season.

Table 3. Sugarcane shoot counts and bermudagrass cover in the fall and spring following at-planting PRE and March POST applications of sulfometuron and standard herbicides.

	Rate		Sugarcane	Bermudagrass cover[a]		
Herbicide	at-planting	spring	shoots[a]	fall	5/94	5/95
	g/ha		no./ha		%	
Sulfometuron[b]	56	22	16,500	7	59	14
Sulfometuron[b]	112	22	16,100	6	41	20
Metribuzin	2,580	2,580	16,900	16	72	17
Weedy check[c]	---	---	15,200	13	88	26
LSD (0.05)			NS	7	16	NS

[a] Sugarcane shoot populations and bermudagrass cover were determined in December after planting with bermudagrass cover being determined again in May of the plant-cane growing season.

[b] Sulfometuron treatments also contained atrazine at 2,240 g/ha.

[c] Atrazine at 2,240 g/ha was applied at-planting and in the spring to the weedy check to insure that bermudagrass was the predominant weed species present.

Table 4. Late-season sugarcane stalk height and gross cane and sugar yields following at-planting PRE and March POST applications of sulfometuron and standard herbicides.

	Rate		Stalk height		Cane yield		Sugar yield	
Herbicide	at-planting	spring	93/94	94/95	93/94	94/95	93/94	94/95
	g/ha		cm		kg/ha			
Sulfometuron[a]	56	22	202	218	67,600	79,900	9,600	9,400
Sulfometuron[a]	112	22	203	203	68,600	80,500	9,600	9,600
Metribuzin	2580	2580	204	221	62,300	86,700	9,000	10,600
Weedy check[b]	---	---	193	220	54,300	84,300	7,700	10,300
LSD (0.05)			7	12	6,900	6,600	1,100	900

[a] Sulfometuron treatments also contained atrazine at 2,240 g/ha.

[b] Atrazine at 2,240 g/ha was applied at-planting and in the spring to the weedy check to insure that bermudagrass was the predominant weed species present.

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IMPACT OF THE CLEAN AIR ACT ON FLORIDA SUGAR MILLS

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ABSTRACT

This paper presents an overview of the Clean Air Act, and how the State of Florida has been implementing the rules and regulation from this Act since the 70's, requiring special attention and large investments from the industry throughout the years. The impact of the amendments on this law is becoming more and more significant, since the industry must comply with regulations which call for limits on the emissions of air pollutants, which could lead us into the installation of very expensive and advanced equipment we can not afford.

The Title V of the Clean Air Act is requiring construction permits for some facilities, and is also calling for the accounting of not only boiler emissions, but for all emissions including fugitive ones of these facilities. Section 129, now under preparation, intends to consider bagasse boilers as incinerators, requiring Maximum Achievable Control Technology to achieve compliance with the new standards.

INTRODUCTION

The Clean Air Act, adopted by The Environmental Protection Agency (EPA) in the seventies has a substantial impact in the sugar industry, particularly in Florida, where the State, through the Department of Environmental Regulation (DER), which is now Department of Environmental Protection requested the installation of pollution control devises to existing and new major sources, such as sugar mill boilers. The DEP set limits to emissions of particulate matter (PM) based on mmBTUs of the heat input. An efficiency of 55% was selected and accepted for the purpose of heat input calculations in compliance tests.

A standard of 0.3 LB/mmBTU determined by EPA's reference test method V was adopted to demonstrate compliance once a year and a BACT (best available control technology) was required for every major source. In those days, the BACTs were the wet scrubbers, which most of the bagasse and residue boilers in the State of Florida now have in service.

By 1975, at a cost of several millions of dollars, all Florida sugar mill boilers had scrubbers installed to comply with the limit of 0.3 LB/mmBTU for particulate matter. Atlantic's boiler # 4 is probably the only one in the state with 0.29 LB/mmBTU because it was a new source at the time and had to have a lower standard than the older ones.

By the late seventies most boilers were passing the annual compliance tests fairly well and some environmentalists started a campaign challenging the legal 55% efficiency as a good value. New concepts like the "F factor" (theoretical volume of flue gas produced by a given fuel), continuos compliance, PM10 (particulate matter smaller than 10 microns), and the impact of other pollutants such as NOx (nitrogen oxides), VOC (volatile organic compounds), and SO2 (Sulfur oxides) was recognized. After a broad study and data collection the DER accepted the 55% efficiency for heat input calculations; but for new sources, limits for other pollutants were established.

DISCUSSION

The fugitive emissions from bagasse handling equipment became an area of concern by the Department of Environmental Regulation (DER), and the industry agreed to "take all the necessary precautions to minimize these fugitive emissions" such as to cover some bagasse conveyors. Atlantic Sugar made a study of rationalization for the bagasse conveyors. Three conveyors were eliminated and several small slats conveyors were substituted by screw conveyors, which generate less "bagacillo" emissions. All dropping points were enclosed and walls were added to the boilers' building to attenuate the effect of the wind to the conveyors. A very satisfactory system of gates and controls was developed to recover the leftover bagasse passing the last boiler and to incorporate it into the bagasse coming from the mill which not only diminished the emissions but provided better feeding to the boilers. The excess of bagasse was dropped at the end of the main conveyor and into an enclosure where it was taken by a front end loader and either fed back to the reclaiming conveyor or taken to the bagasse pile. Since the Clean Air Act also contemplates fugitive emissions and basically all kinds of emissions, it is possible that more modifications to the bagasse handling equipment would be in the near future.

By 1980, the EPA (Environmental Protection Agency) and DER wanted lower PM (particulate matter) standards for new sources, therefore, four new permits were issued with 0.15 LB/mmBTU limit of particulate mater. New federal regulations from EPA required construction permits for new sources, which included a computer model of the facility in order to estimate the impact of air pollutants on surrounding areas , which mean that these boilers are subject to what is called a PSD regulation or "Prevention of Significant Deterioration". A computer model is now required not only for new sources but also when a change or modification that could have a significant environmental impact is anticipated.

Atlantic's boiler 5 was built in 1981, which consequently was a transition time concerning air pollution. It is a PSD boiler with a wet scrubber as BACT to achieve 0.15 LB/mmBTU on PM (particulate matter), but also requires compliance with the emissions of other pollutants such as VOC (volatile organic compounds), NOx (nitrogen oxides), SO2 (sulfur dioxide), and CO (carbon monoxide). Since no data was available for bagasse boilers, the standards were based on AP-42 (EPA publication) factors derived from "similar type of boilers" so we ended with very low allowable emissions for PSD boilers. A good example was CO emissions. In the past the test method for CO emissions was method III or the Orsat apparatus, which is incapable of reporting very low CO concentrations however, when method X was adopted, which is far more precise, we found that the AP-42 factor used underestimated CO emissions which, in reality, are several times higher than those from AP-42.

Wet scrubbers are marginal to achieve 0.15 LB/mmBTU burning bagasse, so the boilers must be in very good shape and very well operated to meet such standards. Furthermore the excess air can have opposite effects on NOx and VOC/CO emissions so there is no room for big variations from the optimum bagasse/air ratio. Bagasse boilers are difficult to “fine tune”, especially when the bagasse is taken directly from the mill tandem which at the same time is propelled by steam turbines fed from the boilers themselves. Dumping and traveling grate boilers with water cooled walls have a quick response to bagasse changes in quantity and quality as well. The boilers’ performance can suffer by the tandem operational changes such as “cuts”, “chokes”, cane plugs, clogging, etc., not to mention cane fiber, trash, mud, mechanical wear of cane knives, scrappers, etc..

The Clean Air Act implementation has been incorporating addenda called Titles, therefore the regulations have become more astringent on emissions. The PM allowable emissions for new sources is now well below 0.15. It is also necessary to comply with PM10 (emission of particulate matter smaller than 10 microns). As we stated before, wet scrubbers are ineffective in the removal of the very small particles. As a matter of fact the scrubber's efficiency is proportional to the particles' size. A different technology such as electrostatic precipitators must be installed to effectively remove more of the tiny particles.

The Sugar Cane League has been monitoring the air quality around the Everglades Agricultural Area year round for PM10 and SO2. The concentration of those pollutants has been well below the maximum allowable values.

New bagasse boilers must achieve compliance on the emission of several air pollutants, requiring new advanced design for good combustion , and better instrumentation for fine tuning, etc. The required pollution control equipment for new boilers will probably fall in the category of what is called "maximum achievable control technology" (MACT). Latest studies revealed that many of our old boilers lack furnace volume to achieve the near perfect combustion required for minimum emission rates that the regulatory agencies are now requesting.

When Palm Beach County was declared a "non attainment area" by EPA in 1991, the Florida Department of Environmental Protection initiated a remedial campaign to resolve the situation. For example it is mandatory to test car emissions of VOC and CO in order to obtain tags and registration in Palm Beach, Broward and Dade Counties. Major sources like mill boilers qualified for the RACT (Reasonable Available Control Technology) program, which means that limits for VOC and NOx are now in effect for all boilers in PBC, even the "grandfather" ones. It has been recognized by DEP that most bagasse boilers do not operate during the "ozone season" of June, July and August, so their operations have no significant impact on the ozone layer, nevertheless the boilers' permits have been modified.

The Title V of the 1990's Clean Air Act also sets a threshold for emission of 189 chemical elements and compounds known as HAPs (hazardous air pollutants). Under Title V a source is the entire facility and units are the individual boilers and any other equipment with the potential to emit regulated pollutants or HAPs. The regulations also establish which sources must apply for a Title V permit based on quantity and nature of air pollutants, as follows:

1- Major sources or those with the potential to emit 100 tons/ year of any regulated pollutant.

2- Sources with the potential to emit 10 tons/year of a single HAP.

3- Sources with the potential to emit 25 tons/ year of different aggregation of HAPs.

4- More than 5 tons/year of Lead.

Example: A mill which grinds 400,000 tons/year of cane with 25% of bagasse % of cane, produces 100,000 tons/year of bagasse for the boilers.

The potential CO emissions using the AP-42 factors is :

CO emissions = 100,000 tons/year x 2 lbs./ton x 1 ton/ 2,000 lb. = 100 tons/year

This mill can be considered a Title V facility and if this is the case, it must apply for a construction permit, no matter how old it really is.

In Florida, working along with other industries and by participation in the rulemaking process, we have accomplished some success in certain areas, such as excluding from the permits some activities which might be considered insignificant from the emissions point of view but just to prove their insignificance could require costly research and testing. It would be extremely costly to test for 189 chemicals just to prove that their emissions are below the threshold set by the regulations. However the Title V facilities are required to somehow demonstrate compliance with the permitted emission limits through testing, monitoring, etc. on a continuos bases.

The continuos assurance monitoring (CAM)rules are still in preparation by EPA, and we do not know at this time what kind of enhancement they will require for existing bagasse boilers which operate seasonally and out of the so called "ozone season" of June, July, and August. Big boilers and new coogeneration facilities are required to employ continuos emission monitoring (CEM) of major air pollutants, which not only implies the equipment but certified technical personnel for calibration and of course state of the art instrumentation to keep the boiler within the emission limits at all times.

We are optimistic that our bagasse boilers will be treated differently, in fact we are requesting other means of demonstrating compliance such as surrogated parameters. We anticipate complicated permits which will require more testing. In fact these new permits will incorporate limits for NOx and VOCs under RACT rules for ozone layer protection, despite the fact that we do not operate in the summer and Palm Beach County is no longer a "non attainment area". We must emphasize that boiler operating fees have been paid annually based on tons of pollutants emitted, excluding carbon monoxide. Under present regulations the owners of major sources paid $25/ ton of pollutants (excluding CO), with a cap of 4,000 tons/year as a maximum fee, which means up to $100,000 per year/facility. We anticipate the top fee of $35 per ton of pollutant in the near future. DEP expressed its intention of financing its own testing program with this money to determine compliance with the emission standards.

Title V facilities, as it was stated above, must report all kind of HAPs (hazardous air pollutants) emissions, including fugitive ones like dust from roads or conveyors, etc.. Other emission points such as vents, open tanks and vessels must be identified, as well as activities which have the potential to generate HAPs.

Section 112 of Title V will regulate HAPs emissions and it is now under development. It looks as if this Section does not represent a major threat to sugar mills immediately but it might make some mills subject to MACT determination upon its completion by the year 2,002. We must emphasize that Title V is a Federal matter. Here in Florida EPA is working closely with DEP, but this may not be the case in other states. The Federal Government could take action if the State fails to implement these rules.

EPA is now preparing a new rule for incinerators under Section 129. Bagasse boilers might be considered as incinerators by the EPA, based on the fact that we burn what they consider to be an agricultural waste. As of the date of this publication, the sugar companies have joined together to act in a proactive participation in the ongoing rulemaking of Section 129. They are trying to establish that bagasse is a fuel and not a waste, therefore, qualifying our boilers as such and not as incinerators. It is almost certain that we will have to claim an exemption from this rule, since we all know that bagasse boilers are exactly that; boilers. The purpose of our boilers is to produce power and process steam.

We know that EPA is considering requesting MACT determinations for the incinerators which will be regulated under Section 129. The preparation of the rules for Section 129 is somewhat unique; the EPA is inviting representatives from different sectors such as industry and also environmentalists to take part. Their intention is to create work groups and a "Coordinating

Committee" to develop the rule. Even when the sugar industry may want to be out of this regulation, we have taken the opportunity to participate in the process, through technical consultants and of course, lawyers. It is my opinion that we should continue to participate in this rulemaking process, but as the whole sugar industry, not Florida alone, since this is a Federal issue concerning all of us.

The future for the Florida Sugar Industry, will include further development of emission control techniques for the boilers, as well as for other areas of the factories, since we still do not know the implications of the Section 112 until it's completion. We should anticipate more sophisticated instrumentation, as well as more personnel training and better skilled personnel, more managerial involvement on pollution matters, and more legal counseling, along with more money being spent.

For other states it is difficult to know how the Federal Government or the State Government will act to enforce the new regulations. We know that EPA is working on their National Combustion Strategy, which includes Sections 111, 112 and 129. The public opinion, media, and politics are also part of the game, in fact, any environmental organization can and has sued the State or EPA whenever they find the regulatory agencies are not doing their jobs correctly.

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SEMINARS

TITLE V PERMITTING WORKSHOP - APRIL 22, 1996 - TAMPA, FLA.

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A PRELIMINARY STUDY ON THE EFFECT OF SUGARCANE LEAVES AND MUD ON COLOR IN SUGARCANE JUICE

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ABSTRACT

During routine sediment tests conducted on cane juice samples from sugarcane stalks containing varying amounts of leafy cane trash and mud (0, 10, 20, and 30%, alone and in combination, by weight of clean cane stalks of the cultivar, CP 70-321), a wide range in color was noted in the supernatant which did not correlate to the sediment load in the juice. From these observations, a series of experiments was conducted to quantify the effect of leafy cane trash and mud on juice color. Results confirmed the deleterious effect of leafy cane trash, to include sugarcane leaf blades and sheaths but no tops, both desiccated and fresh, on juice color, with an approximate 6-fold increase in color over the range in leafy cane trash studied. The effect of leafy cane trash on color appeared nonlinear: color increased at a greater rate with each incremental increase in the level of cane leafy trash. On the other hand, mud (Mhoon silty clay loam with approximately 33% moisture) alone showed a decolorizing effect, due, undoubtedly, to the ion exchange properties of the soil type. Further, the effect of mud on color appeared linear: a decrease of 1.6% in color for each 1% increase in mud added to the cane sample. Leafy cane trash and mud in combination (equal amounts of both leafy cane trash and mud by weight of cane up to a total of 30% trash) showed the opposing effects of the two components: color increased with an increase in total trash but not as much as with the leafy cane trash alone. The overall effect was nonlinear. In summary, it appears that in these preliminary studies leafy cane trash added significant colorant to cane juice while heavy textured soil, i.e., silty clay loam, helped to decolorize cane juice.

INTRODUCTION

Field trash is defined as leaves, tops, dead stalks, roots, soil, etc. delivered together with cane (3). Legendre (6) noted that field trash has increased as a result of mechanical harvesting. Prior to 1943 in Louisiana, the average trash in hand-cut, hand-stripped, and hand-loaded cane was less than 1.9% (6). However, since 1943, field trash levels have increased to over 10% in cane cut and loaded by mechanical means. The same trend has also occurred in Florida.

In studies in South Africa (2), it was reported that with each 1% addition of tops to clean cane the color of clear juice was increased by 1.3% while with each 1% addition of mud to clean cane the color of clear juice was increased by 3.6%. Subsequent studies by Purchase, et al. (9) in South Africa showed that trash contributed substantial color and turbidity to juice. He found that trash appeared to contribute more color than tops alone but when results were normalized there was a linear relationship between color in juice and extraneous material. The composition of the trash was not specifically defined in this work, but based on the nature of the experiments, it probably did not contain field soil or mud. In Australia, Ivin and Doyle (5) defined trash as incorporating the remains of leaves attached to the cane stalk but not including field soil. Further, tops were defined as that portion of the cane stalk above the break point approximately 10 inches in length, minus the top leaves normally cut and blown clear by the cut-chop (combine) harvester. They found that juice color increased an average of 25% with the addition of 6% trash (i.e., a 4.2% color increase for every 1% trash). They also noted a 12% increase in juice color by the addition of 6% green tops (i.e., a 2% increase for every 1% tops); however, the increases in juice color were highly dependent on the cultivar of cane as well, with tops contributing as little as 2% color in one cultivar and as high as 29% color in another. The range for trash effects alone on color by cultivar was from as low as 9.8% to as high as 47.6%

Studies designed to measure relative changes in juice quality are conducted on a continuing basis at the Sugarcane Research Unit, Houma, Louisiana on first-ratoon cane. During routine sediment tests on cane juice, a wide range in cane juice color was noted; color did not always correlate positively to the sediment load in the juice. A series of experiments was set up to quantify the effect on cane juice color of various concentrations of leafy cane trash alone, mud alone, and a combination of leafy cane trash and mud.

MATERIALS AND METHODS

In the present study, leafy cane trash was defined as trash with approximately 60% desiccated and 40% green leaves. The type of field soil (mud) added was Mhoon silty clay loam (Fine-silty, mixed, nonacid, thermic, Typic, Fluvaquents) with approximately 33% moisture. To clean sugarcane stalks of the cultivar, CP 70-321, varying amounts of leafy cane trash and mud (0, 10, 20, and 30%, alone and in combination, by weight of cane) were added. Approximately 100 hand-stripped stalks of sugarcane were shredded through a pre-breaker. To weighed quantities of the clean, chopped cane, the stated proportion of leafy cane trash or mud or the combination of leafy cane trash and mud was added and the mixture homogenized by passing it once again through the pre-breaker. A 2.2 lb subsample was pressed for 2 minutes, 15 seconds in a 3-basket hydraulic press at 2,500 lb/in^2. Each treatment was replicated six times. Fifteen ml of expressed juice from each subsample was centrifuged for 10 minutes at 3,000 RPM according to the sediment test described by Birkett (1). The supernatant was analyzed for color at 420 nm, which is the standard wavelength for ICUMSA color determination (3), and at 560 nm. Samples were filtered on 0.45μ membrane for the determination. A high color reading at 560 nm relative to 420 nm is said to be a measure of the relative amount of very high molecular weight (MW) colorant (7). There was insufficient juice sample to adjust pH to 7.0, so all color measurements were taken at "natural pH". It is possible that leafy trash and/or mud can change pH of juice samples with lower pH, lower color and higher pH, higher color.

RESULTS AND DISCUSSION

Figure 1 shows, in bar graph form, the effect of leafy cane trash, mud, and the combination leafy cane trash/mud mixture on the color of cane juice. Figure 2 shows the effect on color when the data are normalized by the treatments. The mean data for all treatments are shown in Table 1. The deleterious effect of leafy cane trash on juice color was confirmed, with more than a 6-fold increase in color over the treatment range studied. There was a 13% increase in juice color for every 1% leafy cane trash added, up to the 10% level, which is within the range of the Australian experience (5). Mud alone showed a decolorizing effect, due, undoubtedly, to the ion exchange properties of the soil type. The effect of mud was linear with an approximately 1.6% decrease in color per 1% of added mud up to the 30% level. This was contrary to the results found in South Africa where mud also increased the color of juice (2). The results for the combination effects of leafy cane trash and mud mixture reflect the opposing effects of the two components. Color increased from the control but not as much as with leafy cane trash alone because of the decolorizing effect of the mud. The effect, however, was not linear with the rate of color increase going down as the proportion of total trash increased. There was an 11.5% increase in juice color for every 1% combine trash added, up to the 10% level.

Further, there was a trend toward higher MW colorant in juice with leafy trash and lower in juice with mud (data not shown). Also, the mud component, undoubtedly, removed high MW colorant in the leafy trash/mud combination. In this preliminary study, it appears that leafy trash not only increases overall color but also increases the load of high MW colorant.

These results show that the components of trash can have different effects on cane juice color, and it is important to define the composition of the trash. Further, only one cane cultivar was studied, CP 70-321, a cultivar with low cane juice color and low phenolics, known color precursors (4, 8). Further, the Mhoon soil series with its high level of clay has ion exchange properties enabling it to remove color from the juice. Therefore, the soil type is obviously another important factor in determining the effect of trash under field conditions.

However, the harmful effects of mud, such as, contributing to sugar losses in bagasse and filter press mud, increased turbidity and ash, wear and tear to equipment, lowered fuel value of bagasse, etc., would still dictate care in delivering clean, fresh cane to the factory for processing.

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Table 1. Average values for color of centrifuged cane juice determined at 420 nm in the presence of various admixtures of leafy trash and mud (cultivar CP 70-321).

Percentage added	Mud	Leaves	Mud + Leaves
0	2,910	2,910	2,910
5 + 5	-----	-----	6,208
10	2,554	6,665	-----
10 + 10	-----	-----	7,084
20	1,799	12,148	-----
15 + 15	-----	-----	7,645
30	1,315	19,432	-----

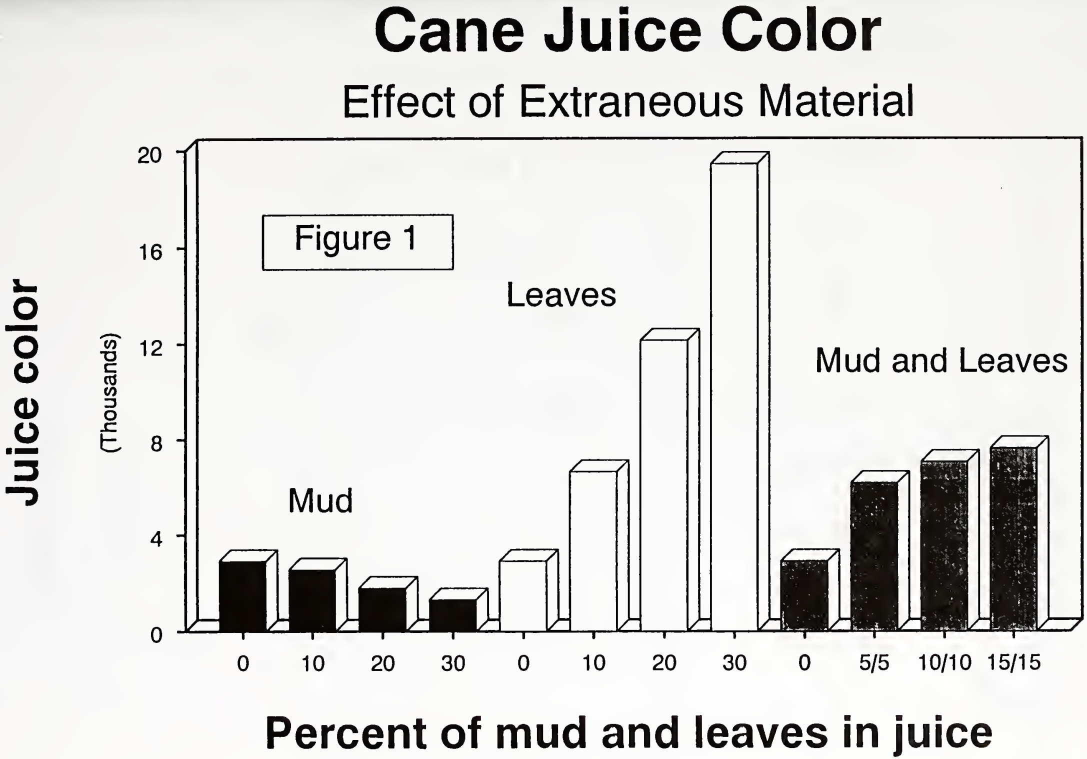

Figure 1. Effect of leafy cane trash, mud, and the combination of leafy cane trash/mud mixture on the color of centrifuged cane juice determined at 420 nm for the sugarcane cultivar CP 70-321.

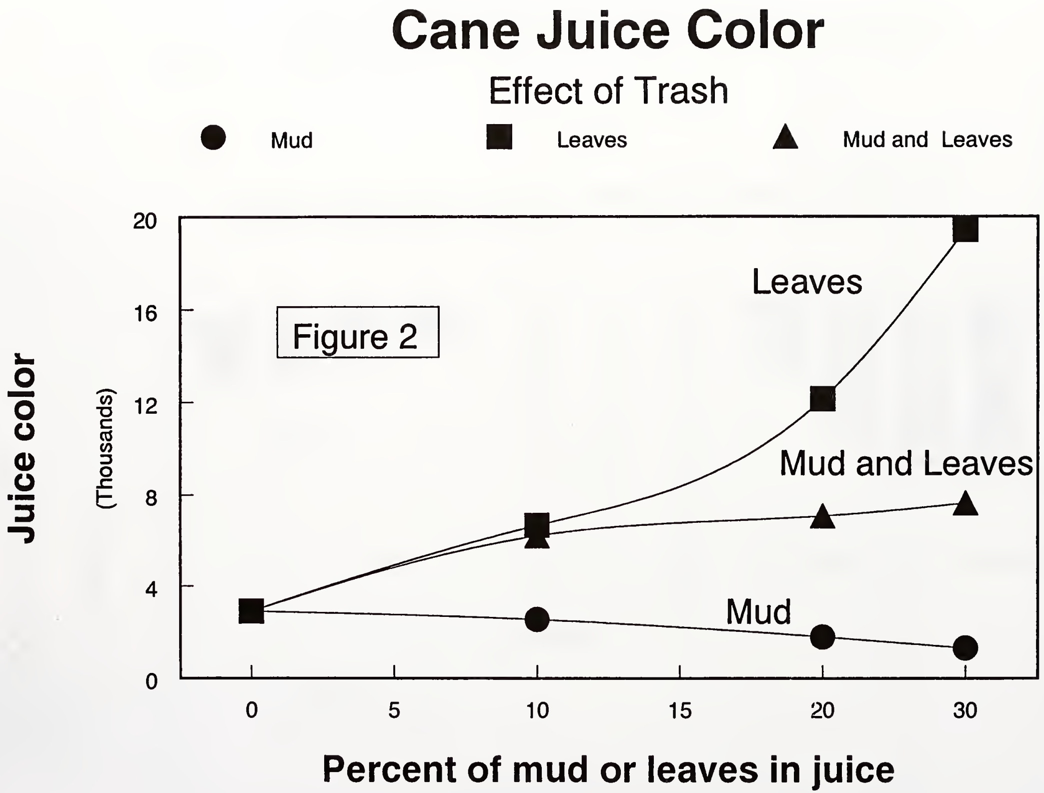

Figure 2. Effect of leafy cane trash, mud, and the combination of leafy cane trash/mud mixture on the color of centrifuged cane juice determined at 420 nm for the sugarcane cultivar CP 70-321 when the data are normalized by the treatments.

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AGRICULTURE ABSTRACTS

WIDESPREAD OCCURRENCE OF YELLOW LEAF SYNDROME IN SUGARCANE CLONES AT CANAL POINT, FLORIDA

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Sugarcane commercial cultivars and parental clones used in the Florida, Louisiana and Texas crossing programs at Canal Point were assayed for the presence of yellow leaf syndrome (YLS). The CP 95 Series clones that had been advanced to the Stage III were also assayed. The sugarcane yellow leaf virus was detected by a polymerase chain reaction (PCR) assay using YLS primers developed by M. S. Irey (US Sugar Corp.) and ELISA using antisera developed by B. E. Lockhart (Univ. of Minnesota). Of the 46 CP parental and/or commercial clones used in Florida only six (CP 57-603, CP 82-1592, CP 89-1509, CP 92-1167, CP 92-1647, and CP 92-1684) were negative in both assays. Of the 71 parental clones used in the Louisiana and Texas breeding programs only four (CP 57-614, CP 92-624, HoCP 93-741, and TCP 91-3543) were negative in both the assays. Of the 136 CP-95 Series clones plus check cultivars in Stage II, 47.8% were positive using the PCR assay. The high incidence of YLS in the CP clones indicates resistance is either lacking or at a low level. The lower incidence in the CP-95 Series clones may reflect a lack of opportunity of infection since the plants had been derived from true seed only two years previously. Although plants with the YLS symptoms usually assayed positive for sugarcane yellow leaf virus, a high number of plants that assayed positive for the virus had no symptoms of YLS. High Brix readings of juice expressed from the midrib were associated with these symptomatic plants. The 46 CP parental clones in Florida program that were assayed had been planted with heat treated seedcane (50°C for 2 hours). This indicates that either the treatment was ineffective or that infection is very quick. Although YLS is widespread, yield losses in Florida have not been quantified. There probably is tolerance to the virus.

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POLYMERASE CHAIN REACTION (PCR) PROTOCOLS FOR DETECTING THE BACTERIA THAT CAUSE LEAF SCALD AND RATOON STUNTING DISEASES OF SUGARCANE

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Two pairs of polymerase chain reaction (PCR) primers were developed that primed specific amplification of the 16S and 23S ribosomal intergenic transcribed spacer region from *Xanthomonas albilineans* and *Clavibacter xyli* subsp. *xyli*, the causal agents of sugarcane leaf scald and ratoon stunting disease, respectively. A PCR protocol using primers PGBL1 and PGBL2 amplified a specific 288 bp DNA product from all *X. albilineans* strains collected worldwide including representatives of serovars I, II, and III. No amplification was observed from sugarcane bacterial saprophytes, *C. xyli* subsp. *xyli*, or other related *Xanthomonas* species tested. Results were obtained in less than two hours. Another PCR protocol with primers Cxx1 and Cxx2 amplified a specific 438 bp DNA product from the genomic DNA of 21 *C. xyli* subsp. *xyli* strains collected worldwide. No amplification of DNA from sugarcane bacterial saprophytes, *X. albilineans*, or other closely related *Clavibacter* species was observed. DNA products can be amplified directly from cultured *X. albilineans* and *C. xyli* subsp. *xyli* cells without prior extraction of the genomic DNA. These two pathogen-specific PCR protocols can be used as diagnostic tools for identification and early detection of the two important sugarcane diseases.

MULTIPLEX POLYMERASE CHAIN REACTION (PCR) FOR DIAGNOSIS OF LEAF SCALD AND RATOON STUNTING DISEASES

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Cloned DNA's from the region between the 16S rRNA and 23S rRNA genes of *Clavibacter xyli* subsp. *xyli*, the causal bacterium of ratoon stunting disease of sugarcane, and from the albicidin gene complex of *Xanthomonas albilinians*, the causal bacterium of leaf scald disease of sugarcane, were sequenced, and the sequences used to design PCR primers for detection of the two pathogens. Different combinations of paired primers were examined for detection of both pathogens in single multiplex reactions. When purified total DNA of each pathogen were tested, a minimum of 25 pg or less of DNA was detected with most primer pairs; however, detection limits in multiplex PCR were adversely affected when DNA of the two pathogens were present in disproportionate amounts. Some primers or combinations of primers produced unexpected amplification products in multiplex PCR.

The relative sensitivity of detection for primer pairs varied for detection of the pathogens in sugarcane extracts, apparently because plant DNA or PCR inhibitors in the extracts had a differential effect on PCR with different primers. Some combinations of primers also produced PCR products when bacterial contaminants isolated from sugarcane were tested. PCR detection of the pathogens, in both single and multiplex reactions, was improved by careful selection of PCR primers and reaction parameters.

IMPACT OF NEMATODES ON SUGARCANE IN LOUISIANA

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Plant and ratoon sugarcane crops were surveyed at 12 locations in Iberville, Ascension, West Baton Rouge, and St. James parishes. Phytoparasitic nematode populations were found to be progressively higher in each successive crop cycle year. Species of *Tylenchorhynchus, Criconemella, Paratrichodorus, Pratylenchus*, and *Helicotylenchus* were found with the greatest frequency.

Two greenhouse trials evaluated nematode pathogenicity and reproduction on five sugarcane cultivars. Plants from single-node cuttings of CP 65-357, CP 70-321, LCP 82-89, HoCP 85-845, and LCP 86-454 were transplanted into 20.3-cm-diameter clay pots containing 4 kg of methyl bromide-treated soil. The soil was infested with 0, 1,000 or 4,000 nematodes (a mixture of stunt, stubby-root, and ring nematodes) per pot. All five cultivars were damaged by the nematodes. Plant height was reduced ($\underline{P} \leq 0.05$) at the high infestation level. Additionally, top and root dry weights were reduced by both high and low nematode levels. Each cultivar supported approximately 50,000 nematodes per pot for each infestation level and cultivar after 4 months.

Microplot experiments were conducted with CP 70-321 and LCP 82-89 in 45.7-cm-diameter pots containing 35 kg of methyl bromide-treated field soil. Three nematode infestation levels (0, 1,200, and 12,000 nematodes per microplot) were employed. For both tests, the inoculum consisted of approximately 35% stubby-root, 35% stunt, and 30% ring nematodes. In 1995, reductions in shoot and root weights were observed for LCP 82-89. Both LCP 82-89 and CP 70-321 supported high nematode populations. In 1996, nematode reproduction was greater on CP 70-321, and there was a reduction in root weight. LCP 82-89 also supported higher nematode reproduction than in 1995; however, growth reductions were not observed.

Nematicide trials were established in Ascension and St. James parishes. Temik 15 G, Mocap 10 G, and Thimet 15 G were applied at the recommend rate at planting. At the St. James location, millable stalks per acre were increased by all three chemical treatments. Cane tonnage was increased only where Temik had been applied, but sugar per acre was increased by Mocap and Temik. At the Ascension site, yield responses were observed in the Temik and Thimet treatments as increases in millable stalks per acre. For both sites, a nematode response to the chemical treatments was not detected.

MORTALITY INDUCED BY *BACILLUS POPILLIAE* IN *CYCLOCEPHALA PARALLELA* (COLEOPTERA: SCARABAEIDAE) HELD UNDER SIMULATED FIELD TEMPERATURES

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The bacterium, *Bacillus popilliae* Dutky, causes milky disease in numerous species of scarabs around the world. *Bacillus popilliae* induced mortality in naturally infected grubs (third instars) of *Cyclocephala parallela* Casey was measured when held under simulated field temperatures. Our data show that visual examination in the field underestimates the percentage of grubs actually infected by *B. popilliae*. 5.6 to 8.2 times as many milky disease infected grubs died during the first 60 days of incubation under simulated field temperatures than did uninfected grubs. These data show that the widely used prevalence value underestimates the total mortality which this bacterium ultimately causes to *C. parallela*.

SEASONAL ACTIVITY OF ADULT LESSER CORNSTALK BORERS (*ELASMOPALPUS LIGNOSELLUS*) AND SUGARCANE BORERS (*DIATRAEA SACCHARALIS*) BASED ON PHEROMONE TRAPPING IN FLORIDA

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Pheromones have proven to be useful management tools for some insect pests. The number of insects collected at traps baited with a pheromone can be used to obtain information on the seasonal dynamics of a pest, to identify areas where a pest is abundant, and to properly time management tactics. Some success has been achieved in managing certain insect species by applying pheromones to disrupt mating. Relatively little has been published on using pheromones in management programs for sugarcane insects in the United States. Research in Florida was conducted to obtain information on using pheromones to monitor two sugarcane pests, the lesser cornstalk borer and the sugarcane borer. Local populations of the lesser cornstalk borer were attracted to traps baited with a synthetic sex pheromone during 1992-1993. Males of this insect were abundant at traps run during the winter and spring, but almost none were collected during late August through late October. The synthetic pheromone should be useful for predicting when lesser cornstalk borer infestations first develop in cane during the fall or winter. Traps baited with virgin female sugarcane borers (no synthetic sex pheromone was available) were used to monitor populations of adult male sugarcane borers during 1996-1997. Relatively large numbers of males (e.g., more than 20) were sometimes collected at the traps. In contrast to males of the lesser cornstalk borer, males of the sugarcane borer were collected throughout the year. No distinct generations of the sugarcane borer were apparent based on the trapping data. The data indicated a synthetic pheromone might be useful in a management program for the cane borer.

PRECISION FARMING APPLICATIONS FOR SUGARCANE IN SOUTH FLORIDA

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A relatively new development in agriculture, known as Precision Farming, is being evaluated for sugarcane in south Florida. It utilizes the Global Positioning System (GPS) to manage crop inputs on a scale as precise as one acre. Recent innovations which make Precision Farming possible are the development of Differential GPS (DGPS), affordable yet fieldworthy microcomputers, and software to link the sample results with their corresponding location and vary the rate of crop inputs such as fertilizer for these sites. Significant acreages cropped in sugarcane in south Florida have already been mapped using DGPS and large variations in a number of soil parameters have been discovered. Contour maps of soil organic matter, pH, available soil silicon and many nutrient elements have been produced by grid sampling of both sand and muck fields. In addition to field mapping of soil test results, a large, self- propelled spinner-type spreader has been equipped with DGPS, rate controller, and on-board computer to apply materials at variable rates based on site-specific soil test results. Since October of 1996, dry fertilizer, calcium silicate slag, and lime have been applied to sugarcane fields using this equipment.

EFFECT OF COMPOSTED MUNICIPAL WASTE AND SUGARMILL WASTE ON SUGARCANE YIELDS AND NITROGEN FERTILIZER REQUIREMENTS

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Municipalities and sugarmills face a growing problem of disposing of their solid wastes. A possible solution to this problem is to use these wastes in agricultural production. Consequently, a sugarcane *Saccharum* interspecific hybrids nitrogen by waste product study (2x6) was initiated in September of 1992. The experiment consisted of twelve treatments that had two rates of nitrogen (0 vs. the recommended N rate) in combination with six compost and waste treatments. Where no nitrogen was used, filter press mud (38.1 t/ha), liquid fish (224 L/ha), and compost (89.7 t/ha), all increased ($P \leq 0.10$) cane tonnage (12.1, 11.2, and 23.1 t/ha) and sugar yield (1490, 1270, and 2540 kg/ha). Where the recommended rate of nitrogen fertilizer was used, only bagasse (33.6 t/ha) and sewage (8.1 t/ha), and compost (89.7 t/ha) increased both cane tonnage (7.4 and 9.2 t/ha) and sugar yield (720 and 1080 kg/ha).

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VARIABILITY OF LEAF PHOSPHORUS AMONG SUGARCANE GENOTYPES GROWN ON EVERGLADES HISTOSOLS

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The phosphorus content of drainage water of the Everglades Agricultural Area (EAA) of Florida must be reduced by at least 25% from a baseline mean calculated using 1978 through 1988 data. This minimum P reduction is one of several measures to sustain much of the unique habitat of remaining natural regions of the Everglades. The objectives of this study were to evaluate variability in leaf tissue P concentration among elite sugarcane (interspecific hybrids of *Saccharum* spp.) clones and to recommend sampling strategies to detect differences among clones. Leaf samples were collected four times per annual crop in the plant-cane and first-ratoon crops from three fields, representing low, medium, and high available soil P. Leaf P of sugarcane should be tested at several locations in at least two crop years, and at least once, but preferably twice per crop. The clone with the most leaf P had 0.65 g P kg^{-1} leaf tissue more than the clone with the least. This difference among leaves allowed us to speculate that P removal may differ by about 8.5 kg ha^{-1} among commercial cultivars and that genetic improvement of this trait could be feasible. If further studies show that differences in leaf P concentration can reliably predict differences in total P removal from a sugarcane field, then classification of cultivars for leaf P concentration could make available to EAA sugarcane farmers another best management practice (BMP) to reduce P content of their drainage waters.

MECHANICAL PLANTING OF WHOLESTALK SUGARCANE IN LOUISIANA

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Renewed interest in mechanical planters prompted by increased farm size and the need for efficiency of time and labor has brought about changes in planter design. The performance of eight mechanical planters were compared to hand planting at two locations during 1993 by measuring the amount of seedcane used, distribution of stalks in the planting furrow and seed-piece damage. Gaps (unplanted space of at least three feet) were measured each spring and yield data were collected during the plant cane and first stubble crops. Comparisons to earlier tests indicate that mechanical planter improvements have reduced the amount of seedcane used and seed-piece damage, but the consistency of the seeding rate is not well enough advanced to reduce planting rates to that of hand planting. In these two tests, a machine planted rate equal to the hand planted rate produced the fewest piles but the most gaps and the lowest yields. Every 1% of rowfeet with gaps of three feet or more resulted in a .14 to .22 ton loss in cane yield.

SOYBEANS IN ROTATION WITH SUGARCANE

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Three experimental sites, differing in soil organic matter content and soil texture, were used to evaluate the influence of fallow-period soybean, *Glycine max* L., occupation on sugarcane, *Saccharum spp*., yield. Fallow-period treatments were a conventional fallow, green manure soybeans and cash crop soybeans. Plant cane N application rates were 0 to 134 kg/ha. All ratoon crops received recommended N fertilizer rates. Sugar yields for all crops of the three cycles were not influenced by the presence of the legume crops during the fallow period. Combined experiment averages were 7,394, 7,270, 7,087, 7,186, 7,183 and 7,461 kg sugar/ha, respectively, for unfertilized cane after fallow, fertilized cane after fallow, unfertilized cane after green manure soybeans, fertilized cane after green manure soybeans, unfertilized cane after cash soybeans and fertilized cane after cash soybeans. The unremarkable differences (P=.12) in sugar yield among treatment averages implies an insensitivity of sugarcane to departure from conventional fallow activities. Differences among the treatments did occur for soil nitrate and plant nitrogen content, but they were relatively modest and did not affect sugar yield. The failure of sugarcane to respond favorably to the additional soil nitrogen contained in soybeans (green manure and cash crop residue) and commercial nitrogen fertilizer forcefully suggests nitrogen was not limiting for growth and development following the fallow period at any of the three sites. If growers do not have to compromise on weed control or seedbed preparation for fall planting, then the costs of the soybean crop should substitute for standard fallow activity and seedbed preparation costs.

GREEN CANE TRASH BLANKET EFFECTS ON WEED AND SUGARCANE DEVELOPMENT IN LOUISIANA

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The ability to effectively harvest high tonnage, lodged cane without burning is the primary impetus for the increase in combine harvester usage in Louisiana. With the combine, leafy trash removed from the stalks is evenly blanketed over the field. Field studies were conducted in second-ratoon fields of CP 70-321 sugarcane in 1994 and 1995 to determine the effects of this green cane trash blanket (GCTB) on weed and cane development.

When removed within 10 days of 1993 and 1994 harvests, the dry weight of the GCTB from the first-ratoon crops averaged 6430 kg/ha and formed a blanket that was approximately 10 cm thick. Cool-season weed infestations in the spring of the second-ratoon crops were at least 62% lower when the GCTB was allowed to remain. The morningglory species comprised the bulk of the warm-season weeds that developed in 1994; warm-season weed development was not observed in 1995. As a complex, the morningglory infestation was 79% lower in 1994 where the GCTB was allowed to remain on the soil surface than where the GCTB was removed the previous fall. The GCTB also suppressed sugarcane shoot development both years. As an average of the two years, sugarcane shoot numbers in March were 29% lower where the GCTB was not removed. As the growing season progressed into August each year, differences in shoot numbers between the ± GCTB treatments decreased. Sugarcane shoot heights were also reduced where the GCTB was allowed to remain but not as dramatically as shoot numbers. Failure to remove the GCTB resulted in a 5 to 6% reduction in gross cane and sugar yields, respectively.

The effects of various removal dates and methods were investigated during the 1996 growing season in a first-ratoon field of CP 70-321. In this study, the GCTB was removed from the row tops on Feb. 27, Mar. 19, and Apr. 4 either mechanically with a revolving disk shaver set to remove the GCTB, emerged shoots, and approximately 1 cm of soil or by hand with a rake that removed the GCTB with minimal disturbance to the emerged shoots. The dry weight of cane residue removed on each date was similar and averaged 7540 kg/ha. Differences in sugarcane shoot numbers and heights for the three removal dates were not detected because of severe freezes on February 3 (-7 C) and March 9 (-2 C). However, it was noted that billets on the soil surface that were covered with the GCTB still had viable buds after the Feb. 3 freeze while buds were killed on billets that were not covered. Gross cane and sugar yields were at least 5% higher where the GCTB was removed either by shaving or raking as an average of all removal dates.

Results suggest that GCTBs can have a beneficial influence on the sugarcane crop by reducing grower dependency on herbicides and by providing some freeze protection to stubble-buds. However, failure to remove the GCTB in the early spring may result in a reduction of cane and sugar yields, at least for CP 70-321 sugarcane grown in Louisiana.

SPRAY DROPLET SIZE OF HERBICIDES AND HERBICIDE/ADJUVANT COMBINATIONS

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In Louisiana off target movement of the herbicide 2,4-D has been well documented especially in cotton producing areas. In 1996, numerous drift complaints were reported for Roundup Ultra. Many factors can be attributed to off target movement of agricultural chemicals and spray droplet size can play an important role. Previous research has shown that droplets less than 105 microns are more susceptible to drift. Studies were conducted to determine droplet sizes of selected postemergence herbicides and herbicide/adjuvant combinations using a Malvern 2600 Laser Particle Analyzer. Herbicide treatments were mixed assuming 15 gallons per acre spray volume and applied at pressures of 30, 40, and 50 psi. Data were expressed as a percent of total spray droplets less than 100 microns.

Roundup Ultra and Roundup (1.5 qts/A), and Roundup D-Pak (30 oz/A) were evaluated alone or in combination with various adjuvants. For individual treatments, in most cases percent of total spray droplet less than 100 microns increased as pressure increased. At all spray pressures, percent of total spray droplets less than 100 microns was equivalent for Roundup Ultra and Roundup plus the nonionic surfactant Induce (0.50% v/v). However, percent of total spray droplets less than 100 microns for Roundup Ultra was at least twice that of Roundup D-Pak plus Induce (1.0% v/v). In contrast, addition of the silicone adjuvant Kinetic HV (0.25% v/v) to Roundup D-Pak almost doubled the percent of small droplets compared with Roundup Ultra.

Graminicides including Assure II, Poast Plus, Select, Fusilade, Fusilade 2000, Fusilade DX, and Fusion at currently recommended rates were also evaluated. Percent of total spray droplets less than 100 microns increased in most cases as pressure increased. At each spray pressure percent of total spray droplets less than 100 microns was equivalent for the graminicides.

Phenoxy herbicides Hi-Dep, Weedar 64, and Weedone LV4 were evaluated at a rate of 3 pts/A. For Hi-Dep and Weedar 64, percent of total spray droplets less than 100 microns was equivalent when applied at 40 or 50 psi. For all pressures, percent of spray droplets less than 100 microns for Hi-Dep and Weedar 64 was at least 3.3 times that for Weedone LV4. Percent of total spray droplets less than 100 microns for the combination of Roundup Ultra and Weedone LV4 was at least half that of Roundup Ultra applied alone.

BERMUDAGRASS CONTROL IN SUGARCANE WITH ROUNDUP AND A HOODED SPRAYER

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Bermudagrass is becoming more prevalent in Louisiana sugarcane fields and currently labeled herbicides used within the crop do not provide adequate control. Roundup and Roundup Ultra applied with a hooded sprayer in April or October were evaluated for bermudagrass control. In one study, CP 65-357 sugarcane was planted in December 1993 and the field was not worked prior to Roundup application on April 26 of the following year. Bermudagrass covered 30 to 70% of the row tops and sides when Roundup plus Induce nonionic surfactant was applied. Hoods were 48 inches wide and covered the row middles leaving a nontreated area approximately 24 inches wide on the row top. Even though wind speed was 7 to 10 mph during Roundup application, no significant sugarcane injury was observed. At 10 days after treatment (DAT), bermudagrass control within the treated area ranged from 84 to 93%. Roundup at 3.5 and 4 quarts/A provided greater control of bermudagrass than 2.5 quarts/A. On July 18, bermudagrass ground cover on the row tops was 90% for the nontreated check, but no more than 32% for the Roundup treatments. Even so, sugarcane stalk population and height in August, and sugarcane and sugar yields were equivalent whether or not Roundup was applied.

In 1995, Roundup plus Induce was applied with a hooded sprayer on October 20 to CP 70-321 sugarcane harvested for seed. Bermudagrass ground cover was approximately 85% and sugarcane regrowth was present at application. Bermudagrass control within the treated area 43 DAT was 68, 80, and 91% for 1, 2, and 3 qts/A, respectively. On May 17 of the following year, bermudagrass coverage of the row top was 28, 24, and 11% for Roundup at 1, 2, and 3 qts/A, respectively, compared with 71% for the nontreated check. Because of the poor sugarcane stand the stubble was destroyed.

In 1996, two experiments were conducted. Roundup Ultra was applied at 2 qt/A on October 15 to CP 70-321 sugarcane planted 8 weeks earlier. Bermudagrass ground cover was variable and approximately 25% in experiment 1 and 40% in experiment 2. Sugarcane was 12 to 15 inches tall with 3 to 5 leaves and wind speed was 7 to 10 mph at application time. Bermudagrass control was compared using a standard hood and one equipped with a Weedseeker^{TM} Model 600 system (Patchen California, Inc.), which consisted of four plant sensors with internal light sources and solenoid/nozzle assemblies. The unique differences in the spectral characteristics of light reflected from green plant material and bare soil can be detected by the sensors allowing herbicide to be applied only when weeds are present. Both hoods were attached to the same tool bar to allow for side-by-side comparisons. Use of the sensor-equipped hood resulted in 29 to 68%

savings (experiment 1) and 5 to 27% savings (experiment 2) in Roundup volume sprayed compared with the standard hood that sprayed continuously. Bermudagrass control on the row tops and in the middles 24 DAT was excellent (98 to 100%) where both the standard and sensor-equipped hoods were used. Ability of sensors to detect weed presence and activate and deactivate solenoids that controlled spray delivery was particularly impressive since ground speed was 5 mph. A slight reduction (5-10%) in sugarcane plant height was observed 24 DAT. On March 21 of the following year, bermudagrass ground cover was no more than 3% in either experiment where Roundup was applied compared with 25% (experiment 1) and 61% (experiment 2) for the nontreated checks. No visual differences in sugarcane height or shoot population were observed between the treated and nontreated plots.

Results indicate that Roundup application with a hooded sprayer can be an effective bermudagrass management tool. Use of a sensor-equipped hooded sprayer significantly reduced herbicide cost without sacrificing bermudagrass control. When Roundup was applied in October the rate required for bermudagrass control was less than when applied in April. Research is underway to determine the effect of fall applications of Roundup on bermudagrass infestation in ratoon crops.

AZAFENIDIN: A NEW BROAD-SPECTRUM HERBICIDE FOR SUGARCANE

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Azafenidin has been under investigation as a possible preemergence herbicide for the control of annual grasses, broadleafs, and sedges in citrus, sugarcane and grapes. In Louisiana, it has been evaluated under the code name DPX-R6447 as an at-planting, preemergence application in the fall and as a postemergence to the crop but preemergence to seedling weeds application in the spring in plant-cane crops of sugarcane in both sandy and clay soils at rates of 0.56 to 1.12 kg ai/ha. To date, azafenidin applied at planting at rates of 0.56 to 1.12 kg ai/ha has provided good to excellent control of a number of cool-season weeds including: ryegrass, Carolina geranium, purslane, henbit, and sowthistle. March applications of azafenidin at similar rates has controlled many warm-season seedling weeds including: johnsongrass, junglerice, itchgrass, and a number of morningglory species. Acceptable (>60%) levels of purple and yellow nutsedge control have also been observed with at-planting and March applications of azafenidin, particularly at the higher rates.

Sugarcane injury following at-planting applications of azafenidin at rates up to 1.12 kg/ha was minimal 4 weeks after treatment averaging 10% or less. When azafenidin was applied postemergence to the crop in the spring some crop injury in the form of a reddening of the treated leaves was observed within 7 days of treatment. The injury was generally transient in nature and rate-dependent and was not evident as a reduction in harvestable sugarcane stalk counts, heights,or weights or as a reduction in gross cane and sugar yields when compared to standard applications of metribuzin at 2.0 kg ai/ha, terbacil at 1.6 kg ai/ha, and mixtures of pendimethalin with atrazine each at 3.0 kg ai/ha.

Azafenidin offers several advantages over currently used preemergence herbicides. It controls ryegrass and itchgrass better than at-planting and spring applications of terbacil and metribuzin and is less affected than pendimethalin by environmental extremes. Its postemergence activity on seedling weeds may be less than that observed with terbacil and metribuzin, however.

To insure control of weeds that may be emerged at the time of application, particularly when applications are made in the spring, azafenidin may have to be partnered with other herbicides.

NEGATIVE RELATIONSHIP BETWEEN SUCROSE AND TONNAGE IN SUGARCANE: IMPLICATIONS FOR A BREEDING PROGRAM

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Plant breeders select an array of traits or characters to develop a cultivar. In sugarcane, total sugar per hectare (determined by total tonnage and sucrose concentration) is of primary concern. Their contribution to total sugar have different effects, and increasing one could be at the expense of the other. The objectives of this paper were to illustrate how, through the use of an economic index, clones that are somewhat ambiguous in merit can be selected amongst, and how the relationship between sucrose and tonnage can differ when viewed from an economic rather than a biological perspective. Data from 20 years of selection of Stage IV in the Canal Point breeding program were analyzed. The 164 clones and three crops provided 492 observations. Correlation and regression analyses were conducted. The economic index proved extremely useful in balancing the yield variables. The correlation between sucrose and tonnage variables did not show a consistent negative relationship. A different perspective was obtained when the two variables were plotted using the rankings from the economic index, allowing the evaluation of biological variables for how they contribute to the economics of the crop.

INTRAROW PLANT SPACING AND FAMILY BY ENVIRONMENT INTERACTION EFFECTS ON SUGARCANE CROSS EVALUATION

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Cross evaluation via progeny testing is used to select the best crosses (families) prior to individual plant selection, and to guide hybridizing and seedling planting decisions by personnel in the Louisiana Sugarcane Variety Development Program. Research to optimize the progeny testing methodology examined the relative importance of cross, within cross, years, locations, replication and intrarow plant spacing on the effectiveness of the testing procedure. Variances component analysis indicated that cross by environment (locations, years) interaction is only a minor inhibitor of selection effectiveness. Within-field variance is the largest source of variation for the five traits considered (plant weight, stalk number per plant, stalk weight, stalk diameter and stalk length). For stalk weight, length and diameter, the slim majority of this within-field variance is due to genetic within family plant-to-plant variation. Partitioning of plant-to-plant variation for plant weight and stalks per plant was not possible. Cross by spacing interaction was not important as evidenced by the genetic correlations of family means of the same trait at different spacings and cross by spacing interaction variance component magnitude. These genetic correlations were

essentially unity. Estimates of direct and correlated response to selection showed that wider spaced family (81 cm between plants) results was more effective than narrowly spaced testing (41 cm between plants) and selection. Since cross by environment variances were minor compared to other sources of variation, testing scenario effectiveness was mostly a function of plant number and spacing. Replication across environments only marginally improved selection effectiveness. Predicted gain for almost all traits demonstrated from 20 to 31% increase in selection effectiveness by using widely spaced plants. The only exception was stalk diameter which showed between 2 and 4% increase. Results from this study strongly suggest that selection using widely spaced plants would be more accurate than narrowly spaced plants.

BREEDING STUDIES OF THE DWARF, MULTIPLE BUD, AND RED LEAF MUTANTS OF SUGARCANE

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Mutants are the foundation of genetic variation without which the identification, isolation, and analysis of genes would be impossible. There are no registered mutants of sugarcane, which further hinders genetic analysis of this high-level, complex polyploid. Our laboratory has a collection of plants with stable mutant phenotypes, i.e., dwarf, multiple bud, and red leaf. We are evaluating the morphology and inheritance of mutant characteristics with the objective of registering the mutants as genetic stocks. Two dwarf clones were developed from callus culture of the sugarcane variety LCP 83-137. Dwarfs were unresponsive to exogenous application of gibberellic acid (GA_3). Flowering of this mutant has not been previously reported. Dwarf was male sterile and female fertility was low. Segregation analysis of two crosses (70 progeny) in which dwarf was the female parent showed that the trait was qualitatively transmitted at a ratio of about 1 dwarf : 2 normal. Compared to LCP 83-137, the dwarf stature appeared to be caused by reduced internode length. As expected, agronomic performance of dwarf tended to be inferior to either LCP 83-137 or its normal sibs. Multiple bud could reduce seed cane requirements, thus it is a trait with potential agronomic value. However, its rarity in the population suggests that the trait has little selective advantage. Field studies of seven multiple bud clones of diverse parentage showed that multiple bud mutants were generally comparable to checks in millable stalks per stool. Two mutants (MB 84-3065 and US 93-14) equaled the checks in TRS, and three (MB 84-3065, US93-13, and US 94-12) equaled the checks in shoot and stalk numbers. We evaluated 1800 progeny from 19 crosses in which one parent was multiple bud. Multiple bud was transmitted at low frequency - only 40 progeny (2%) expressed the trait. A previous report by Irvine et al. (1991) indicated that multiple bud is expressed only intermittently. Thus, transfer of the multiple bud trait to a sugarcane cultivar would be difficult. Red leaf mutants were progeny of CP 55-30 RL, an extinct, red-leaved variant of the cultivar CP 55-30. Segregation analysis of seven crosses having a red-leaved parent (813 progeny) were in the ratio of 1 strong red leaf : 1 weak red leaf : 2 green progeny. Red leaf progeny had decreased stalk weight, length, and diameter compared to green progeny. The mutants may be useful as morphological and molecular markers in genetic studies of sugarcane.

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MANUFACTURING ABSTRACTS

FAST-TRACK TO MILLING CONTROL

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The commitment of the milling train is to exact as much pol as economically possible from sugar cane. It does so through mechanical operations, i.e., shredding, crushing, and leaching, grouped under the generic term "milling." Managing an efficient train implies a different viewpoint from normal day-to-day operation's. Unfortunately, operational challenges seem more urgent than performing efficiently; most plant personnel attend to the important job of running a dependable train, while they might need help seeing the challenge from the viewpoint of recovering sugar, reducing bagasse losses.

The efficiency of the milling process is measured as "Pol Extraction," or the proportion of pol extracted percent on pol in cane. Determination of Pol Extraction requires both analyses and calculation, as well as sampling of juice and bagasse. Samples are taken on a certain schedule, and some of them may be composed for several hours. Analyses of the composite samples are performed, again on a schedule, and at the end of the day Extraction is calculated and reported. Thus, the mill engineer gets his feedback from the Lab with a considerable time lag.

Insofar as the sugar mill is a machine designed to extract juice, and since it cannot tell pol from impurities, then it is only logical for the millwright to use brix to grade efficiency of his train, as brix can be measured easily at millsite. Thus, a couple of spindles and cylinders will help us estimate an Extraction that correlates well with Pol Extraction, which can be used advantageously for the controlling function of management, as it eliminates the time lag. However, determination of this extraction must not be encumbered with the calculation involved, and in order for the mill foreman to perform the task himself, a suitable nomograph must be used.

Significant linear relationships between the level of brix degrees of the first and the last expressed juices and the Extraction have been derived using industrial data. Weekly data from the last eight crops, as appeared in the S.C.G.C. of Florida Weekly Technical Reports were used. Inordinate scatter of the data from three crops, associated with either unusually high extraction, or abnormally high grinding rate, or else, the grinding of stale cane after a freeze, made them candidates for dismissal; they were retained, however, to make an expression generic for the whole spectrum of performance from poor to outstanding, even though error for average results is thereby magnified. Ratio brix of last expressed juice / brix of crusher juice was regressed against extraction. A linear regression by the method of least squares yielded an expression that was used to construct the nomograph.

This paper describes the foreman's nomograph, and shows a comparison of our millsite figures for Extraction, vis-à-vis the Lab's Pol Extraction.

COMPUTERS IN THE SUGAR FACTORY

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In today's technical world, computers are an unavoidable, and sometimes, overwhelming reality. However, very often, there is much confusion as to what computers can and can't do in our sugar mills, and as to where and when they should be used.

The objective of this presentation will be to: 1) dissipate many, if not all, of the misconceptions and myths surrounding their purpose and use in the sugar factory, 2) explain the reasons why we should take advantage of the computer technology in the sugar industry, and 3) issue recommendations on how to develop and implement a plan to "computerize" a sugar factory.

SUMMARY OF MILLING STUDIES IN LOUISIANA (1992-1996)

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Summary results of mill tests conducted in Louisiana from 1992 through 1996 will be presented. Included in the presentation will be moisture, fiber, ash, individual and cumulative extraction plots. Open cells across the tandem and imbibition efficiencies will also be presented. Data on special tests conducted will also be shown.

MILL IMPROVEMENT PROGRAM AT ST. JAMES SUGAR COOP., INC. AN UPDATE

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The second step in the three-pronged program to improve mill efficiency at St. James Sugar Coop., Inc. was accomplished for the start of the 1995 grinding season. An assessment of the results for the 1995 and 1996 crops showed the targeted improvements were attained.

THE BARANDALLA TRASHPLATE: THE MINIMAL FRICTION SPIRAL

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All along the 1991-92 harvest, S.C.G.C.'s milling trains faced a hard time. Suffering from severe steam shortages, our mills barely managed to grind their commitment for the first half of the crop. In February 1992, however, as fiber content increased substantially along with the proportion of mature canes coming in, the turbines driving the first two mills of each train began slowing down under load and eventually stalling from either the permanent lack of steam, or frequent episodes of low steam pressure.

Having no other options, the immediate and frustrating expedient of releasing some hydraulic pressure from several mill rams to reduce horsepower demand proved costly: sucrose in bagasse went up, and the mill performance was spoiled for the remainder of the crop, never to recover. Probably, the only place to cut down energy demand of the cane sugar mill without sacrificing performance is at the trashplate. During that month, in an attempt to prevent future fiascoes, a study was conducted to explore the possibility to reduce friction losses, and the "Barandalla Trashplate" was born as a result. We have been using it ever since.

Bergmann, of the Java Experimental Station, had shown more than a century ago that the trashplate profile should be that of a logarithmic spiral wound around the top roll center. Now, the "Barandalla" (Basque for "February") affords the least friction spiral layout for any given mill. It may be shown that the friction loss at the trashplate is a function of roll radius, of front mill opening, of the angle included for the subtended spiral arc of the trashplate profile, of a constant inherent to the logarithmic spiral, and of the coefficient of friction between bagasse and iron.

Real-life calculations of trashplate friction, some tables useful in the selection of least friction "Barandallas" for every occasion, and the conclusions that follow are included in the paper.

IMPROVING GEAR BOX DURABILITY

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The wear life of a gear box can be greatly extended with a good gear replacement selection process and a good preventive maintenance (PM) program. The PM program should include periodic inspections of the gear teeth for wear, analysis of the lubrication for contaminants, and measurements of bearing endplay and operating temperatures. This paper will provide a discussion of several preventive maintenance practices and illustrate the benefits of a comprehensive program. The paper will also discuss factors that should be considered during a gear replacement selection process.

DETECTION OF SUGAR IN MULTIPLE EFFECT EVAPORATOR CONDENSATE SYSTEMS USING FLUORESCENCE

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Condensate from the multiple effect evaporators used for concentrating sugar juice is frequently reclaimed and returned to the boiler. Evaporator condensate typically contains few contaminants and has a relatively high Btu value, making the condensate an ideal candidate for reuse as makeup water to the boiler. Occasionally, the condensate becomes contaminated with sugar from the process. Such "sugar shots" cause a depression in boiler water pH as the sugars break down into organic acids. Fluorescent monitoring techniques were successfully used to detect

low concentrations of sugar jiuice in evaporator condensate. Second effect evaporator condensate was monitored on-line at the American Crystal Sugar Plant. Fluorescence readings were directly compared to a sodium analyzer and alpha naphthol readings. In addition, bench testing was completed on samples from several sugar cane mills as well. Development and field trial data will be discussed in the paper.

IMPROVED CLARIFICATION THROUGH INCREASED INORGANIC PHOSPHATE CONCENTRATIONS WITH A NOVEL ENZYME

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BASF's Natuphos 5000L is a natural *Aspergillus niger* enzyme, which frees up inorganic phosphate from phosphorus containing organic molecules present in the cane juice. Optimum operating conditions are: 98°C, pH 5.5 to 7.0 and 15 to 20 min. reaction time. When added to the primary juice, it may increase the P_2O_5 levels by 10 to 30%. This improved the Bogstra-ratio: $P_2O_5 / (SiO_2 + Al_2O_3 + Fe_2O_3)$ in several cases to over 0.25 and the corresponding suspended solids level to less than 500 mg/L, yielding a better clarified juice.

THE FREEZE OF 1997: THE GOOD, THE BAD, AND THE UGLY (A GENERAL MANAGER'S VIEW)

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The objective is to make a general and practical presentation of the effects of the Freeze of January 19, 1997 on a particular Florida Sugar Mill (Atlantic), with no warm lands, and limited cane supply (1,200,000 tons). The presentation will show: a. Graphs of the sucrose of the leading cane varieties before and after the freeze, b. Graphs of mill yields before and after the freeze, c. Graphs of dextran levels both direct from the field, in the yard, and in trailer storage, d. Discussion of managing strategies to cope with the changing conditions of the cane in: 1. burning, 2. harvesting, 3. grinding, 4. fabrication, and 5. storage with regard to climatological, scheduling, fields, and geographical situation.

LOSSES OF SUCROSE IN BILLET CANE FROM WASH WATER

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At several of the factories in Louisiana Dr. Willem Kampen attained some samples of wash water and analyzed it for sugar content. At each of the mills he estimated a flow rate for the water and the cane in the feed table. From these data Dr. Kampen could determine the amount of sucrose, glucose, and fructose lost in the wash water. At the Florida ASSCT meeting I will report on these findings. The presentation will follow the brief outline: Introduction, Identification of the mills involved (angles of feed table, styles of feed tables, and flow rates of water and cane), graph

of the relation of water flow to cane flow, graph of the relation of water flow to sucrose lost, graph of the relation of cane flow to water flow, mathematical relationships, conclusions, and questions.

POST-HARVEST MANAGEMENT OF BILLETED CANE FOR OPTIMAL CANE AND JUICE QUALITY

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Increasing environmental regulations may soon restrict or reduce the extent of field burning in Louisiana for the removal of leafy trash from sugarcane stalks prior to harvest. Further, there is evidence that field burning of whole-stalk cane may actually reduce sugar yield even though little or no deterioration products can be detected in the juice. Many growers are using cane combines to harvest newer varieties of sugarcane which produce higher tonnages but are subject to lodging. The combine chops the cane stalks into billets of 7 to 14 in (17.5 to 35.0 cm) and, with the aid of extractor fans, removes a significant portion of the leafy trash without burning. The number of cane combines operating in Louisiana has increased from 2 three years ago to more than 60 during the 1996-97 harvest. It is anticipated that for the 1997-98 harvest, the number of combine harvesters operating in Louisiana will double and that 50% of the crop will be harvested with this system. Although the combine can harvest green cane, many growers are burning standing cane prior to harvest to increase the efficiency of the harvester. Experience in other countries has shown that burned and/or billeted cane deteriorates faster than whole stalk cane.

To evaluate post-harvest management of billeted cane in Louisiana for optimization of cane and juice quality, two field experiments comparing green vs. burned and whole vs. billeted cane of two varieties, CP 70-321 and LCP 85-384, were conducted during the 1996-97 harvest season. Samples of whole stalks of green and burned cane were harvested by hand in standing cane while samples of green and burned, billeted cane were taken directly from the elevator of the cane combine operating in the fields. Average billet length in both experiments was 10.1 in (25.7 cm). Estimated yield (stalks per acre X average stalk weight)of gross cane per acre averaged 45.8 and 45.5 tons (102.7 and 102.0 tons/ha) for CP 70-321 and LCP 85-384, respectively.

Whole and chopped stalks of both green and burned cane were milled within 24 h of harvest and at 1, 2, and 3 d intervals thereafter. Cane samples were analyzed for fiber content while juice samples were analyzed for Brix, sucrose, purity (ratio of sucrose to Brix), and dextran concentration. Samples for delayed milling were stored in a greenhouse at 80 °F (26.6 °C) and high humidity (60-100%) which had been found in previous studies to contribute to a significant increase in dextran concentration of juice within a 24-h period in billeted cane but not whole-stalk cane.

Whole stalks of green and burned cane harvested by hand had a trash content of 15.5 and 11.8% for CP 70-321 and 10.9 and 5.8% for LCP 85-384, respectively. Trash content of green and burned, billeted cane averaged 9.9 and 8.4% for CP 70-321 and 14.8 and 10.0% for LCP 85-384, respectively. The higher level of trash, to include cane tops, in the green cane harvested by combine increased fiber content. The higher fiber content would be expected to lower extraction and, with the non-sucrose solids expected from the processing of cane tops, also lower boiling house efficiency, and, in the final outcome, lower overall sugar recovery.

Deterioration rate and dextran concentration were variety dependent, higher in billeted cane than whole-stalk cane (2,136 vs. 199 ppm, respectively, for CP 70-321 and 9,033 vs. 233 ppm, respectively, for LCP 85-384, as an average of both burned and unburned cane for all dates of milling), and higher in burned cane than in green cane (1,221 vs. 1, 1 13 ppm for CP 70-321, respectively, and 6,211 and 3,055 ppm, respectively, for LCP 85-384, as an average of both whole-stalk and billeted cane for all dates of milling). Chopping appeared to have a greater deleterious effect on juice quality than burning with burn to crush management also crucial to juice quality when harvesting cane by combine. On the other hand, no significant increase in dextran concentration was noted in either green or burned, whole-stalk cane for either variety.

In summary, harvest management of billeted cane is the key to optimizing cane quality while post-harvest management is the key to juice quality. The dextran concentration of juice found in these experiments for either green or burned, billeted cane necessitates that cane be processed in a timely fashion. Further, the dextran concentration in sugar is linked to the dextran in juice and is likely to exceed industry standards (250 M.A.U.) when green, billeted cane of CP 70-321 is held for up to 48 h but only 24 h or less for burned, chopped cane at the conditions outlined in the study. However, for LCP 85-384 the standard would be exceeded in both green or burned, billeted cane within 24 h. Finally, results from previous studies have shown that with lower ambient temperatures, i.e. 50 °F (10 °C), and/or with lower relative humidity, rapid deterioration as found in these studies is less likely to occur.

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS EDITORIAL POLICY

Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

Frequency of publication:

The Journal will appear at least once a year. At the direction of the Joint Executive Committee, the Journal may appear more frequently. Contributed papers not presented at a meeting may be reviewed, edited, and published if the editorial criteria are met.

Editorial Committee:

The Editorial Committee shall be composed of the Managing Editor, Technical Editor for the Agricultural Section, and Technical Editor for the Manufacturing Section. The Editorial Committee shall regulate the Journal content and assure its quality. It is charged with the authority necessary to achieve these goals. The Editorial Committee shall determine broad policy. Each editor will serve for three years; and may at the Joint Executive Committee's discretion, serve beyond the expiration of his or her term.

Handling of manuscripts:

Four copies of each manuscript are initially submitted to the Managing Editor. Manuscripts received by the Managing Editor will be assigned a registration number determined serially by the date of receipt. The Managing Editor writes to the one who submitted the paper to inform the author of the receipt of the paper and the registration number which must be used in all correspondence regarding it.

The Technical Editors obtain at least two reviews for each paper from qualified persons. The identities of reviewers must not be revealed to each other nor to the author during the review process. Instructions sent with the papers emphasize the necessity for promptness as well as thoroughness in making the review. Page charges will be assessed for the entire manuscript for non-members. Members will be assessed for those pages in excess of ten (10) double spaced Times New Roman (TT) 12 pt typed pages of 8 1/2" x 11" dimension with one (1) inch margins.

When a paper is returned by reviewers, the Technical Editor evaluates the paper and the recommendations of the reviewers. If major revisions are recommended, the Technical Editor sends the paper to the author for this purpose, along with anonymous copies of reviewers' recommendations. When the paper is returned to the Technical Editor, he/she will judge the adequacy of the revision and may send the paper back to any reviewer for further review. A paper sent to its author for revision and held more than 6 months will be given a new date of receipt when returned. This date will determine the priority of publication of the paper.

A paper rejected by one reviewer may be sent to additional reviewers until two reviewers either accept or reject the paper. If a paper is judged by two or more reviewers as not acceptable for the Journal, theTechnical Editor returns it to the author along with a summary of the reasons given by the reviewers for the rejection. The registration form for the paper is filled out and returned to the Managing Editor along with copies of the reviewers' statements and a copy of the Technical Editor's transmittal letter to the author. The names of all reviewers must be shown on the registration form transmitted to the Managing Editor.

When a paper is recommended by two reviewers for publication in the Journal, it is read by the Technical Editor to correct typographical, grammatical, and style errors and to improve the writing where this seems possible and appropriate, with special care not to change the meaning. The paper is then sent by the Technical Editor to the Managing Editor who notifies the authors of the acceptance of the paper and of the probable dates of publication. At this time, the Managing Editor will request a final version in hardcopy and on diskette in WordPerfect format from the corresponding author.

Preparation of papers for publication:

Papers sent by the Technical Editor to the Managing Editor are prepared for printing according to their dates of original submittal and final approval and according to the space available in the next issue of the Journal.

The paper is printed in the proper form for reproduction, and proofs are sent to the authors for final review. When the proofs are returned, all necessary corrections are made prior to reproduction. The author will be notified at the appropriate time to order reprints at cost.

Any drawings and photographs for the figures in the paper are "scaled" according to their dimensions, the size of lettering, and other factors. They are then sent to the printer for camera work. Proofs of the illustrations are sent to the authors. Any changes requested at this stage would be expensive and authors will be expected to pay the cost of such changes.

Reprinting in trade journals has the approval of the Editorial Committee provided: a) no article is reprinted before being accepted by the Journal; b) credit is given all authors, the author's institutions, and the ASSCT; and c) permission of all authors has been obtained. Summaries, condensations, or portions may be printed in advance of Journal publication provided the approval of the Editorial Committee has been obtained.

RULES FOR PREPARING PAPERS TO BE PRINTED IN THE JOURNAL OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

Format

Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION (OR RESULTS AND DISCUSSION), CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized. Scientific names shall be italicized.

All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. If using WordPerfect, set the bottom margin at 0.5 inches. This will set the page number at 0.5 inches and the final line of text at 1 inch from the bottom margin. Exactness in reproduction can be insured if electronic copies of the final versions of manuscripts are submitted. Authors are encouraged to contact the managing editor for specifics regarding software and formatting software to achieve ease of electronic transfer.

Authorship

Name of the authors, institution or organization with which they are associated, and their locations should follow the title of the paper.

Abstract

The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

Tables

Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Use TAB function rather than SPACE BAR to separate columns of a table.

Figures

Number the figures consecutively and refer to them in the text as Figure 1, Figure 2, etc. Each figure must have a legend. Figures must be of sufficient quality to reproduce legibly.

Drawings & Photographs

Drawings and photographs must be provided separately from the text of the manuscript and identified on the back of each. Type figure numbers and legends on separate pieces of paper with proper identification. Drawings and photographs should be of sufficient quality that they will reproduce legibly.

Reference Citations

The heading for the literature cited should be REFERENCES. References should be arranged such that the literature cited will be numbered consecutively and placed in alphabetical order according to the surname of the senior author. In the text, references to literature cited should be made by name of author(s) and year of publication from list of references. Do not use capital letters in the titles of such articles except in initial words and proper names, but capitalize words in the titles of the periodicals or books.

Format Example

ITCHGRASS *(ROTTBOELLIA COCHINCHINENSIS)* *CONTROL* IN SUGARCANE WITH POSTEMERGENCE HERBICIDES

Reed J. Lencse and James L. Griffin
Department of Plant Pathology and Crop Physiology
Louisiana Agricultural Experiment Station, LSU Agricultural Center
Baton Rouge, LA 70803

and

Edward P. Richard, Jr.
Sugarcane Research Unit, USDA-ARS, Houma, LA 70361

ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

RESULTS AND DISCUSSION

Table 1. Visual itchgrass control and sugarcane injury as influenced by over-the-top herbicide application at Maringouin and Thibodaux, LA, 1989.

CONCLUSIONS

ACKNOWLEDGMENTS

REFERENCES

GUIDELINES FOR PREPARING PAPERS FOR JOURNAL OF ASSCT

The following guidelines for WordPerfect software are intended to facilitate the production of this journal. Authors are strongly encouraged to prepare their final manuscripts with WordPerfect 6.0 or a later version for Windows. Please contact the Managing Editor if you will not use one of those software packages.

Paper & Margins: All material (including tables and figures) shall be submitted on 8½ x 11 inch paper with one inch margins on all sides. To achieve this with WordPerfect, set the top, left, and right margins at one inch. However, set the bottom margin at 0.5 inches. This will place the page number at 0.5 inches and the final line of text at one inch.

Fonts: Submit your document in the Times New Roman (TT) 12pt font. If you do not have this font, contact the Managing Editor.

Alignment: Choose the full alignment option to prepare your manuscript. The use of SPACE BAR for alignment is not acceptable. As a general rule SPACE BAR should only be used for space between words and limited other uses. Do not use space bar to indent paragraphs, align and indent columns, or create tables.

Do not use hard returns at the end of sentences within a paragraph. Hard returns are to be used when ending paragraphs or producing a short line.

Place tables and figures within the text where you wish them to appear. Otherwise, all tables and figures will appear after your References section.

Styles: ***Italicize*** scientific names. Do not use underline.

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1. Smith, I. M., H. P. Jones, C. W. Doe, 1991. The use of multidiscipline approaches to control rodent populations in plants. Journal of American Society of Plant Management. 10:383-394.

CONSTITUTION OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

As Revised and Approved on June 21, 1991
As Amended on June 23, 1994
As Amended on June 15, 1995

ARTICLE I

Name, Object and Domicile

Section 1. The name of this Society shall be the American Society of Sugar Cane Technologists.

Section 2. The object of this society shall be the general study of the sugar industry in all its various branches and the dissemination of information to the members of the organization through meetings and publications.

Section 3. The domicile of the Society shall be at the office of the General Secretary-Treasurer (as described in Article IV, Section 1).

ARTICLE II

Divisions

The Society shall be composed of two divisions, the Louisiana Division and the Florida Division. Each division shall have its separate membership roster and separate officers and committees. Voting rights of active and honorary members shall be restricted to their respective divisions, except at the general annual and special meetings of the entire Society, hereinafter provided for, at which general meetings active and honorary members of both divisions shall have the right to vote. Officers and committee members shall be members of and serve the respective divisions from which elected or selected, except the General Secretary-Treasurer who shall serve the entire Society.

ARTICLE III

Membership and Dues

Section 1. There shall be five classes of members: Active, Associate, Honorary, Off-shore or Foreign, and Supporting.

Section 2. Active members shall be individuals residing in the continental United States actually engaged in the production of sugar cane or the manufacture of cane sugar, or research or education pertaining to the industry, including employees of any corporation, firm or other organization which is so engaged.

Section 3. Associate members shall be individuals not actively engaged in the production of sugar cane or the manufacture of cane sugar or research pertaining to the industry, but who may be interested in the objects of the Society.

Section 4. Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to 5 living Honorary members assigned to the two Divisions jointly.

Section 5. Off-shore or foreign members shall be individuals not residing in the continental United States who may be interested in the objects of the Society.

Section 6. Supporting members shall be persons engaged in the manufacturing, production or distribution of equipment or supplies used in conjunction with production of sugar cane or cane sugar, or any corporation, firm or other organization engaged in the production of sugar cane or the manufacture of cane sugar, who may be interested in the objects of the Society.

Section 7. Applicants for new membership shall make written application to the Secretary-Treasurer of the respective divisions, endorsed by two members of the division, and such applications shall be acted upon by the division membership committee.

Section 8. Minimum charge for annual dues shall be as follows:

Active Membership --------------------------- $10.00
Associate Membership ----------------------- $25.00
Honorary Membership ----------------------- NONE
Off-shore or Foreign Membership ----------- $20.00
Supporting Membership --------------------- $50.00

Each Division can assess charges for dues more than the above schedule as determined by the Division officers or by the membership at the discretion of the officers of each Division.

Dues for each calendar year shall be paid not later than 3 months prior to the annual meeting of the member's division. New members shall pay the full amount of dues, irrespective of when they join. Any changes in dues will become effective in the subsequent calendar year.

Section 9. Dues shall be collected by each of the Division's Secretary-Treasurer from the members in their respective divisions. Unless and until changed by action of the Joint Executive Committee, 50 percent of the minimum charge for annual dues, as described in Section 8 for each membership class, shall be transmitted to the office of the General Secretary-Treasurer.

Section 10. Members in arrears for dues for more than a year will be dropped from membership after thirty days notice to this effect from the Secretary-Treasurer. Members thus dropped may be reinstated only after payment of back dues and assessments.

Section 11. Only active members of the Society whose dues are not in arrears and honorary members shall have the privilege of voting and holding office. Only members (all classes) shall have the privilege of speaking at meetings of the Society.

ARTICLE IV

General Secretary-Treasurer and Joint Executive Committee

Section 1. The General Secretary-Treasurer shall serve as Chief Administrative Officer of the Society and shall coordinate the activities of the divisions and the sections. He or she will serve as ex-officio Chairperson of the Joint Executive Committee and as General Chairperson of the General Society Meetings, and shall have such other duties as may be delegated to him or her by the Joint Executive Committee. The office of the General Secretary-Treasurer shall be the domicile of the Society.

Section 2. The Joint Executive Committee shall be composed of the elected members of the two division Executive Committees, and is vested with full authority to conduct the business and affairs of the Society.

ARTICLE V

Division Officers and Executive Committee

Section 1. The officers of each division of the Society shall be: a President, a First Vice-President, a Second Vice-President, a Secretary-Treasurer or a Secretary and a Treasurer, and an Executive Committee composed of these officers and four other members, one from each section of the Division (as described in Section 3 of Article VII), one elected at large, and the President of the previous Executive Committee who shall serve as an Ex-Officio member of the Division Executive Committee. The office of the Secretary-Treasurer in this constitution indicates either the Secretary-Treasurer, or the Secretary and the Treasurer.

Section 2. These officers, except Secretary-Treasurer, shall be nominated by a nominating committee and voted upon before the annual division meeting. Notices of such nominations shall be mailed to each member at least one month before such meeting. Ballots not received before the annually specified date will not be counted.

Section 3. The Secretary-Treasurer shall be appointed by and serve as a non-voting member at the pleasure of the Division Executive Committee. The Secretary-Treasurer may not hold an elected office on the Executive Committee.

Section 4. The duties of these officers shall be such as usually pertain to such officers in similar societies.

Section 5. Each section as described in Article VII shall be represented in the offices of the President and Vice-President.

Section 6. The President, First Vice-President, and Second Vice-President of each Division shall not hold the same office for two consecutive years. Either Section Chairperson (as described in Section 3 of Article VII) may hold the same office for up to two consecutive years. The terms of the other officers shall be unlimited.

Section 7. The President shall be elected each year alternately from the two sections hereinafter provided for. In any given year, the Presidents of the two Divisions shall be nominated and elected from different sections. The President from the Louisiana Division for the year beginning February, 1970, shall be nominated and elected from the Agricultural Section. The president from the Florida Division for the year beginning February, 1970, shall be nominated and elected from the Manufacturing Section.

Section 8. Vacancies occurring between meetings shall be filled by the Division Executive Committee.

Section 9. The terms "year" and "consecutive year" as used in Articles V and VI shall be considered to be comprised of the elapsed time between one annual division meeting of the Society and the following annual division meeting of the Society.

ARTICLE VI

Division Committees

Section 1. The President of each division shall appoint a committee of three to serve as a Membership Committee. It will be the duty of this committee to pass upon applications for membership in the division and report to the Secretary-Treasurer.

Section 2. The President of each division shall appoint each year a committee of three to serve as a Nominating Committee. It will be the duty of the Secretary-Treasurer of the Division to notify all active and honorary members of the Division as to the personnel of this committee. It will be the duty of this committee to receive nominations and to prepare a list of nominees and mail this to each member of the Division at least a month before the annual meeting.

ARTICLE VII

Sections

Section 1. There shall be two sections of each Division, to be designated as:

1. Agricultural
2. Manufacturing

Section 2. Each active member shall designate whether he or she desires to be enrolled in the Agricultural Section or the Manufacturing Section.

Section 3. There shall be a Chairperson for each section of each Division who will be the member from that Section elected to the Executive Committee. It will be the duty of the Chairperson of a section to arrange the program for the annual Division meeting.

Section 4. The Executive Committee of each Division is empowered to elect one of their own number or to appoint another person to handle the details of printing, proof reading, etc., in connection with these programs and to authorize the Secretary-Treasurer to make whatever payments may be necessary for same.

ARTICLE VIII

Meetings

Section 1. The annual General Meeting of the members of the Society shall be held in June each year on a date and at a place to be determined, from time to time, by the Joint Executive Committee. At all meetings of the two Divisions of the Society, five percent of the active members shall constitute a quorum. The program for the annual meeting of the Society shall be arranged by the General Secretary-Treasurer in collaboration with the Joint Executive Committee.

Section 2. The annual meeting of the Louisiana Division shall be held in February of each year, at such time as the Executive Committee of the Division shall decide. The annual meeting of the Florida Division shall be held in September or October of each year, at such time as the Executive Committee of that Division shall decide. Special meetings of a Division may be called by the Executive Committee of such Division.

Section 3. Special meetings of a Section for the discussion of matters of particular interest to that Section may be called by the President upon request from the respective Chairperson of a Section.

Section 4. At Division meetings, 10 percent of the active division members and the President or a Vice-President shall constitute a quorum.

ARTICLE IX

Management

Section 1. The conduct and management of the affairs of the Society and of the Divisions including the direction of work of its special committees, shall be in the hands of the Joint Executive Committee and Division Executive Committees, respectively.

Section 2. The Joint Executive Committee shall represent this Society in conferences with the American Sugar Cane League, the Florida Sugar Cane League, or any other association, and may make any rules or conduct any business not in conflict with this Constitution.

Section 3. Four members of the Division Executive Committee shall constitute a quorum. The President, or in his or her absence one of the Vice-Presidents, shall chair this committee.

Section 4. Two members of each Division Executive Committee shall constitute a quorum of all members of the Joint Executive Committee. Each member of the Joint Executive Committee, except the General Secretary-Treasurer, shall be entitled to one vote on all matters voted upon by the Joint Executive Committee. In case of a tie vote, the General Secretary-Treasurer shall cast the deciding vote.

ARTICLE X

Publications

Section 1. The name of the official journal of the Society shall be the "Journal of the American Society of Sugar Cane Technologists." This Journal shall be published at least once per calendar year. All articles, whether volunteered or invited, shall be subject to review as described in Section 4 of Article X.

Section 2. The Managing Editor of the Journal of the American Society of Sugar Cane Technologists shall be a member of either the Florida or Louisiana Divisions; however, he or she shall not be a member of both Divisions. The Division affiliation of Managing Editors shall alternate between the Divisions from term to term with the normal term being three years, unless the Division responsible for nominating the new Managing Editor reports that it has no suitable candidate. The Managing Editor shall be appointed by the Joint Executive Committee no later than 6 months prior to the beginning of his or her term. A term will coincide with the date of the annual Joint Meeting of the Society. No one shall serve two consecutive terms unless there is no suitable candidate from either Division willing to replace the current Managing Editor. If the Managing Editor serves less than one year of his or her three-year term, another candidate is nominated by the same Division, approved by the other Division, and appointed by the General Secretary-Treasurer to a full three-year term. If the appointed Managing Editor serves more than one year but less than the full three-year term, the Technical Editor from the same Division will fill the unexpired term of the departed Managing Editor. In the event that the Technical Editor declines the nomination, the General Secretary-Treasurer will appoint a Managing Editor from the same Division to serve the unexpired term.

Section 3. The "Journal of the American Society of Sugar Cane Technologists" shall have two Technical Editors, which are an Agricultural Editor and a Manufacturing Editor. The Managing Editor shall appoint the Technical Editors for terms not to exceed his or her term of office. Any Technical Editor shall be a member of either the Louisiana or Florida Division. Each Division will be represented by one technical editor at all times unless the Executive Committee of one Division and the Managing Editor agree that there is no suitable candidate willing to serve from that Division.

Section 4. Any member or nonmember wishing to contribute to the Journal of the American Society of Sugar Cane Technologists shall submit his or her manuscript to the Managing Editor. The Managing Editor shall then assign the manuscript to the appropriate Technical Editor. The Technical Editor shall solicit peer reviews until, in the opinion of the Technical Editor, two responsible reviews have been obtained that either accept (with or without major or minor revision) or reject the manuscript. For articles accepted with major revision, it shall be the responsibility of the Technical Editor to decide if the authors have satisfactorily completed the major revision(s). The Technical Editor may solicit the opinion of the reviewers when making this decision. The Technical Editors shall not divulge the identity of any reviewer. The Managing Editor shall serve as Technical Editor of any manuscript which includes a Technical Editor as an author.

ARTICLE XI

Amendments

Section 1. Amendments to this Constitution may be made only at the annual meeting of the Society or at a special meeting of the Society. Written notices of such proposed amendments, accompanied by the signature of at least twenty (20) active or honorary members must be given to the General Secretary-Treasurer at least thirty (30) days before the date of the meeting, and he or she must notify each member of the proposed amendment before the date of the meeting.

ARTICLE XII

Dissolution

Section 1. All members must receive notification from the General Secretary-Treasurer of any meeting called for the purpose of terminating the Society at least thirty (30) days prior to the date of the meeting. After all members have been properly notified, this organization may be terminated at any time, at any regular or special meeting called for that purpose, by an affirmative vote of two-thirds of the total honorary and active members in good standing present at the meeting. Thereupon, the organization shall be dissolved by such legal proceedings as are provided by law. Upon dissolution of the Joint Society, its assets will be divided equally between the two Divisions of the Society. Dissolution of the Joint Society will not be cause for automatic dissolution of either Division. Upon dissolution of either Division, its assets will be divided in accordance with the wishes of its members and in conformity with existing IRS regulations and other laws applicable at the time of dissolution.

ARTICLE XIII

Assets

Section 1. No member shall have any vested right, interest or privilege of, in, or to the assets, functions, affairs or franchises of the organization; nor any right, interest or privilege which may be transferable or inheritable.

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June, 1999

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Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to 5 living Honorary members assigned to the two Divisions jointly. (Article III, Section 4 of the Constitution of the American Society of Sugar Cane Technologists).

Following is the list of the living Honorary members of the American Society of Sugar Cane Technologists for Florida, Louisiana and Joint Divisions:

Florida Division

Guillermo Aleman
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1998 OUTSTANDING PRESENTATION AWARDS

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B.L. Legendre, M.P. Grisham, M.A. Clarke and M.A. Goodshall. Sugarcane Agriculture: Impact on Processing.

J. Hoy, Z. Yin, L. Rodriguez, C. Richard, W. Jackson and H. Waguespack. Comparison of Billet and Whole Stalk Planting.

D. Day and L. Plhak. Dextran Analysis: Current Technology, Future Prospects.

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PRESIDENT'S MESSAGE
FLORIDA DIVISION

Dr. Edgar Aguirre
United States Sugar Corporation

On behalf of the Executive Committee of the Florida Division of Sugar Cane Technologists, I extend my warmest welcome to the participants and guests of the 28th Joint Meeting of the American Society of Sugar Cane Technologists.

Our society was founded several decades ago with the objective of promoting the general study of the sugar industry in all its various branches and the dissemination of information to its members through meetings and publications. Since its beginning the ASSCT has lived up to these expectations by promoting, encouraging, and assisting in the development of the sugar industry. Hundreds of technical papers detailing technological advances in sugarcane production as well as in sugar manufacturing have been presented at both division and joint meetings and published in the ASSCT Journal. The success of our society in meeting its objectives can be attributed to two factors: first, the commitment of its members to solve the more challenging technological problems facing the sugar industry, and second, to their willingness to share those findings with colleagues for the benefit of the industry as a whole. May I congratulate you and thank you for all your hard work and dedication.

Traditionally, the Division Presidents deliver an annual address in which they review the past, discuss the present, and present their predictions for the future. Before writing this address, I decided to read some past presidential addresses, and I must confess that after reading such well thought out and inspiring manuscripts, I felt profoundly humble and wondered if what I had to say would sound half as good. My wife then pointed out that after 30 years in the sugar industry, my version of the past, present and future might hold some interesting wisdom of its own.

The harvest season of 1997/98 has been a long and wet one. As we all know, El Nino, the weather phenomenon originating off the coast of Peru in South America, has brought drought to some parts of the world and floods to others. Evidently, El Nino brought Florida warm weather and frequent heavy rains forcing mills to stop for unscheduled downtime. Usually, this combination of warm weather and rain has a detrimental effect on the quality of the cane coming to the mills. Under these circumstances, the trash percent cane and dextran are normally high. As a result, the daily grinding is reduced, the filter cake production is high, the exhaustion of final molasses is difficult, and the boiling house efficiency decreases. In spite of stop-and-go operations, the seven mills in Florida ground 16,935,039 short tonnes of 100 percent mechanically harvested cane that came from about 440,000 acres of land. On the production side, 1,923,308 short tonnes of sugar raw value were produced along with 102,014,414 gallons of final molasses of 79.5 ° Brix.

Presently, the Florida sugarcane industry is enjoying an apparent tranquil time compared to the recent past few years. This is the time when we should concentrate our efforts on planning for the future by setting objectives that center around agricultural research, harvesting, transportation, application of new technology to sugar manufacture, among others. One vital link to this chain, which I believe has not been emphasized in the past, is the education of the public at large of our contributions to the environment and the local and national economy. I would like to take the liberty of addressing this topic first.

In the last 30 years, I have witnessed some major political crises: Florida referendum on Amendment 4, Sugar Acts, NAFTA, and GATT. My belief is that these crises may have been avoided had we educated the general public about our industry. As I mentioned earlier, our society has done an excellent job on the dissemination of information to the members of its organization; however, these times require more. We need to increase public awareness so that when lawmakers draft laws and citizens vote they can make informed decisions based on facts, not fiction or emotion. With this in mind, I would like to ask the members of our society to carefully consider officially expanding the bylaws to include a committee dedicated to education of the public at large.

The Florida Division has started the educational process in the Glades by taking on a more active role in the community. This year some of our Executive Committee members volunteered their time by participating as judges at the Science and Engineering Fair in West Palm Beach, Florida. The winners received scholarships funded by ASSCT membership dues. In addition, the grant received from the ASSCT Joint Executive Board in 1997 was used to help continue our efforts in promoting sugarcane and environmentally related science projects for high school students. These are but a few examples of how we can positively impact our community on an educational level, but we need to do more. Your participation is critical to our success.

There is a well-known phrase in Florida that describes the Everglades swamp of decades ago as "The River of Grass." Those swamps were and still are the ideal habitat for many unique and threatened species. Through time, parts of those swamps have been transformed into agricultural land, and part of "The River of Grass" has become "The River of Sweet Grass." Along the banks of this imaginary New River, small towns and their small businesses have prospered and enriched the culture and economy of South Florida and the country as a whole. Many Americans view the heartland of America only as the Midwest, failing to associate southern Florida and its rich heritage with this American ideal. The sugarcane industry is a living example of the productive partnership that can exist between man and nature. It is our responsibility to ensure that our efforts do not go unnoticed by the rest of the country.

In addition to educating the public at large, we should continue our efforts on developing our research programs in the fields and factories to meet the "sugar industry' future demands.

In Florida, sugarcane growers have successfully implemented natural control strategies by taking advantage of sugarcane's natural tolerance to most pest species, especially to those that attack foliage. Biological control, through the use of beneficial insects to control insect pests, has become an important part of integrated pest management programs in Florida. It has been reported that over 80% of the sugarcane in Florida is often grown without receiving a single foliar pesticide application for insets, mites, or disease over the course of an entire year. The success of the production of sugarcane in Florida has been attributed to both the planting of sugarcane varieties resistant to bacterial, fungal, and viral diseases and to integrated pest management programs. To capitalize on environmentally sound pest control tactics, United States Sugar Corporation opened a large Beneficial Insect Laboratory for the purpose of raising and releasing beneficial organisms for insect control.

The Sugarcane Field Station at Canal Point continues its proud tradition of conducting important genetic, pathological, and agronomic research for the Florida sugarcane industry. In addition, USDA at Canal Point has cooperative agreements with both the Louisiana and Texas industries to conduct genetic research for the sugarcane industries in those states. Currently, scientists at the University of Florida and Canal Point are working to genetically improve the natural ability of the sugarcane plant to tolerate short-term flood, to improve the yield with use of less phosphorus fertilizer, and to improve the plant's ability to remove phosphorus from the soil. Hopefully, within a few more years, the sugarcane industry will have in commercial production new cane varieties with these highly desirable traits.

USDA-Agriculture Research Service supplies the majority of the funding that keeps Canal Point running. However, we must recognize that the Florida Sugar Cane League provides about 23 percent of the funding for Canal Point. The University of Florida provides some support, which many of us agree needs to be strengthened back to traditional levels. This year, the U. S. Congress and President Clinton approved an additional $500,000 in annual funding for Canal Point. This money is targeted to assist Florida sugarcane growers in strengthening their tradition of responding positively to issues linking the health of the Everglades to farming in the Everglades Agricultural Area. Several ASSCT scientists have worked on these issues in the past, and the industry is pleased that USDA-ARS has agreed that scientists at Canal Point should also be an integral part of this effort. I would also like to acknowledge U. S. Sugar Corporation's commitment to the long-term cooperative project with Canal Point through the loan of land and scientists. Their actions have aided in persuading lawmakers of our needs for the additional funding.

In Queensland, Australia, sugarcane farmers are trying dual row planting which is claimed to increase the yield by 20 percent. Researchers in the same country have pointed out that by using the "close row system" the increase in yield would be over 50 percent. However, this type of planting, dual row or close row, requires that the conventional planting and harvesting machines be modified to accommodate the new system. Therefore, collaboration from agricultural machine manufacturers is essential. The use of dual row, close row, system along with the planting of phosphorus-reducing varieties would be the ideal combination for the Florida sugarcane farmers whose objective is to obtain the maximum reduction of phosphorus content in the agricultural runoff to the Everglades.

I mentioned in my presentation the terms trash percent cane and dextran. The magnitude of each of these terms is closely related to the harvesting system and transportation schedule to the cane to the mills. In Florida, 100 percent of the sugarcane is machine-harvested. With the introduction of machine harvesting, the trash percent cane has increased as compared to that of hand cut cane. In Florida, with mills of high capacity, a value of trash percent cane equal to 5.0 represents one week of extra grinding time. Obviously, there is an economic incentive to reduce the trash percent cane coming to the mills. The factors that affect machine harvesting should be exhaustively investigated for both the type of farm and the type of harvester with the clear objective of reducing the amount of trash in cane sent to the mills to a minimum.

During warm and humid weather, the dextran content in the cane coming to the mills is related to the time between cutting and grinding. The time effect is exponential and accelerates drastically after the first 12 to 14 hours. Therefore, the "waiting time" is critical to keep the dextran content in the juice at manageable levels. I am sure most of you know of dextran's adverse effects on sugar manufacturing. In general, the factory throughput is reduced, the viscosity of the material increases, the loss of sucrose in the final molasses is high, and the dextran content in the raw sugar increases. Consequently, to avoid heavy economic losses to the processors, optimization of the transportation schedule is a must. This schedule should target a 12 to 14 hours maximum for the total time the cane is cut before milling.

The typical cane raw sugar manufacture process, namely milling, clarification, evaporation, crystallization, and centrifugation, has essentially been the same for the last several decades. However, plant managers and their staff are constantly working to improve the efficiency of each unit operation and at the same time improve the quality of the raw sugar. Energy efficiency is on the top of the list. In this regard, the ratio of pounds of steam as generated from the boilers per tonne of cane ground is a number to watch closely. On the subject of factory related research, we have seen over the last twenty years some publications on membrane technology as applied to sugar manufacture; however, its full acceptance into the cane raw sugar industry has not been that successful yet. Recently, cooling has published preliminary results on a procedure for sugar crystallization by cooling. If this research continues, we will see the final results in the near future. On the operational side, equipment maintenance is critical for the continuous operation of a sugar mill. The use of Predictive Maintenance technology is highly recommended. This technology provides much of the data that are required to improve the performance of plant manufacturing and process systems. The introduction of microprocessor-based multi-meter intelligent sensors along with computer software programs that automate data acquisition has eliminated the boundaries for the use of this technology in the manufacturing plants.

Research, innovation, and exploration of new opportunities are at least three of the characteristics of a successful enterprise in a competitive industry. Today's sugar industry in the United States needs to have more or all of the attributes. As an example of a company exploring new opportunities, the United States Sugar Corporation will bring into production the first new cane sugar refinery built in Florida in the last twenty-five years. The new refinery will change the company's output from bulk non-food grade raw sugar to retail/industrial food grade white sugar. With this new production line, the U. S. Sugar Corporation will be a player in four distinct markets: raw sugar, refined sugar, citrus and plastics. This type of diversification allows sugar companies in the United States the chance at an optimistic future.

In conclusion, I would like to leave you with this thought: The difficult times that the sugar industry has endured in the past, whether it be because of weather, cane diseases, state and national politics, or foreign political pressure, have undoubtedly united this industry. The agricultural research in the fields and the technological improvements in the factories brought about by members of this organization have allowed the sugar industry to thrive even under the harshest conditions. Although, the agricultural research in the fields and technical improvements in the factories are critical for our future success, we also need to emphasize on those characteristics that make companies successful in other competitive industries. I am confident that with due planning our society can meet the challenge of continued technological support for the sugar industry into the new millennium thus ensuring its growth and prosperity in the years to come.

PRESIDENT'S MESSAGE
LOUISIANA DIVISION

Herman Waguespack, Jr.
American Sugar Cane League of the U.S.A., Inc.

On behalf of the membership of the Louisiana Division of the American Society of Sugar Cane Technologists, I express my sincere thanks to the Florida Division for hosting the Twenty-Eighth Annual Joint Meeting in St. Petersburg Beach, Florida. I am confident that this year's meeting will again encourage a healthy exchange of ideas and technology for the progress of the U.S. sugarcane industry.

It is with great pleasure that I report on Louisiana's record-breaking production during 1997. A total of 12,019,441 tons of cane were ground by 19 factories producing 1,275,000 tons of sugar, raw value. This marked the fourth year of sugar production over 1 million tons. Approximately 380,000 acres were harvested for sugar providing a phenomenal state average yield of 31.8 gross tons of cane per acre and 6,710 pounds of sugar per acre.

To what do we owe the successful season? Most will agree that several factors played an important role in this record-setting yield. Much credit can be given to the good weather conditions during the growing season, with no major tropical storms to upset the crop. A drier than normal harvest period allowed growers to capture the yield produced in the field without bringing in too much mud to the factories. So again, Mother Nature has greatly influenced the outcome. But, let us not forget the decades of concerted effort dedicated to breeding and selecting varieties adapted to our environment and the improvement of management practices needed to take advantage of the growing conditions. Research conducted cooperatively by state, federal and industry scientists has evolved into an integrated system of varieties, cultural practices, pest management, as well as harvest and processing technology to continuously improve our efficiency as an industry. Increased efficiency has been foremost in the minds of industry leaders who recognize that proper implementation of the latest technology available is vital to the future success of the sugarcane industry.

Whether the technology is classed as futuristic or conventional, the long term goals of the industry must be kept in mind. The Louisiana sugarcane industry has actively supported research to improve both field production and raw sugar processing. While a small, but significant portion of funds are used to explore high risk research such as biotechnology, traditional techniques of variety improvement through the use of wild germplasm are yielding enormous benefits. In search of disease resistance we have also found increased yield and stubbling ability. What a better tribute to the researchers we have come to rely on for our very existence as an industry! The enterprising individuals that have focused on progress have laid the groundwork. It is up to each of us to continue to provide leadership and thus maintain a competitive edge.

While the ongoing investigations of alternate uses for sucrose and co-products are encouraging, research on raw sugar processing continues to focus on factory efficiency. Utilization of computer technology is being looked upon to reduce milling costs by factory automation and reduction of labor requirements. Sugar losses during processing continue to be of concern especially in light of combine harvested cane supplies. As many are aware, the Louisiana sugar industry is in a time of transition. Few changes have ever had as great an impact on the productivity of the Louisiana sugar industry as the concurrent acceptance of LCP 85-384 along with the combine harvest system. Within a few short years this new, high yielding variety has been expanded onto a large percentage of the state's acreage. Along with this variety shift, combine harvesters have gained acceptance such that approximately half of the 1997 crop was combine harvested. Along with these changes there are many opportunities for research to guide the industry in the right direction to assure that increased productivity equates to increased profitability. Some of the present challenges include billet planting, row configuration and cultivation, residue management, accurate cane quality determinations, and coordination of wholestalk and combine deliveries.

Issues in the legislative arena continue to challenge our industry. Since the signing of the 1996 farm bill there has been talk of the year 2003 and the fact that there may not be another farm bill to replace this one. Will this really happen? Your guess is as good as mine. But, what is certain is that trade issues reverberating from the NAFTA and GATT compacts continue to take new meaning. As Mexico and its neighbors to the south ready themselves for "open" borders, a close watch must also be kept on the Cuban situation as well as the push by other sugar producing South American countries that want inclusion in the NAFTA. The commercial users of sugar continue their pursuit of eliminating what is left of the sugar program. They have enlisted the environmental groups as was witnessed last year with the sugar tax in Florida. They are now conducting grass root letter writing campaigns against our supporters, nationwide, who are up for re-election. The politics of sugar are no longer an every four to five year battle, it has now become an annual affair with no signs of slowing down.

As increased production costs continue to erode profit margins, the industry is faced with ever increasing regulations on pesticide usage, highway transport, air and water quality issues, solid waste concerns and a host of other related matters. How can real progress be made when a significant portion of time and money is spent trying to satisfy concerns based on public sentiment instead of sound scientific fact? Perhaps now, more than ever, long term research goals must be clearly defined and accountability for our limited resources of time, talent and treasure is a must. Defining and implementing a course of action for the industry to thrive, not merely survive, in a global economy is perhaps the greatest challenge of the day. We must all focus, communicate, cooperate and coordinate for the future!

Finding solutions to the many problems that face the industry is not an easy task. Providing answers on a timely basis is even more difficult. The importance of technology transfer through meetings such as this one and various extension related activities should not be underestimated. Cooperation and communication remain integral parts of the sugar industry. May we always be willing to do both and may the information learned contribute to the continued success of the sugarcane industry.

PEER

REFEREED

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SECTION

DISTRIBUTION OF THE LEAF SCALD PATHOGEN IN INFECTED SUGARCANE STALKS

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ABSTRACT

Polymerase chain reaction (PCR) and isolation on a semi-selective medium methods were used to study the within-stalk distribution pattern of the leaf scald bacterium, *Xanthomonas albilineans*. Xylem sap samples from every elongated internode (at least 1 cm in length) of 11 pairs of infected symptomatic vs. asymptomatic stalks were examined for *X. albilineans*. When internodes were grouped into upper, middle and lower thirds, no significant difference in mean percentage of detection was found between the two methods. *Xanthomonas albilineans* was detected by both methods in nearly every internode in the middle and lower thirds of symptomatic stalks. The mean percentages of detection in these two thirds of the symptomatic stalks were significantly higher than the mean percentage of detection in the upper third of the symptomatic stalks and in all the three sections of asymptomatic stalks. However, no significant differences were found among the mean percentages of detection for the three sections of asymptomatic stalks. This suggests that distribution of *X. albilineans* was random among internodes of asymptomatic stalks. It is recommended that as many as 20 stalks be collected across a field , where no leaf scald disease symptoms exist, and that a composite of xylem sap samples from six internodes per asymptomatic stalk, two randomly from each third, be used for diagnostic tests.

INTRODUCTION

Leaf scald, caused by *Xanthomonas albilineans* (Ashby) Dowson, is a serious sugarcane disease and can cause significant loss to cane yield and sugar quality (Hoy and Grisham, 1994; Ricaud and Ryan, 1989). Control of the disease relies on the use of resistant cultivars and on planting disease-free seed cane. Certification of clean seed cane requires a reliable method of detection and guidelines for collecting samples. This is particularly true when attempting to detect latent infections, a characteristic of this disease (Ricaud and Ryan, 1989). Recently, a sensitive polymerase chain reaction (PCR) protocol was developed by our laboratory (Pan et.al., 1997). Using this PCR protocol, as few as five colony forming units (CFU) of *X. albilineans* per reaction were detected from infected sugarcane sap or leaf diffusate (Pan et.al., 1997).

Vascular sap is commonly used in disease diagnosis of sugarcane. Unlike ratoon stunting disease (RSD) (Davis et.al., 1980; Gillaspie and Teakle, 1989) where the basal internodes are recognized as the optimal sampling location for the causal bacterium, *Clavibacter xyli* subsp. *xyli* (Harrison and Davis, 1988), there is no agreement among researchers as to which portion of the stalk should be sampled in diagnosis for leaf scald. Two previous studies explored *X. albilineans* distribution within sugarcane plants (Comstock and Irey, 1992; Rott et.al., 1994) using isolation on semi-selective culture media and serological assay techniques. Comstock and Irey (1992) used tissue blot immunoassay, ELISA, and isolation techniques to determine that internodes located 62.5% up from the base of the stalk were the best sample site for *X. albilineans* in both symptomatic and asymptomatic stalks. Rott et al. (1994) used an antibiotic-resistant mutant *X. albilineans* strain and a plate-count procedure to show that the basal internodes of inoculated stalks had a stable population over time and appeared to be the best location to assay for the pathogen. However, other tissue also should be assessed since sugarcane roots, leaves, and apices contained culturable populations (Rott et.al., 1994). Samples included in these two studies did not include every elongated internode. Samples were taken at internode positions 12.5, 37.5, 62.5, and 87.5% up from the base of the stalk by Comstock and Irey (1992), and only one sample was taken from the lower third of each stalk by Rott et al. (1994). The objective of this study was to investigate in greater detail the within-stalk distribution of *X. albilineans* in infected symptomatic and asymptomatic sugarcane stalks using both the PCR and isolation on semi-selective medium methods.

MATERIALS & METHODS

In late November and early December of 1996, two stalks, one symptomatic and one asymptomatic, were collected from 11 sugarcane plants grown at the USDA Sugarcane Research Unit, Houma, LA. Five of the plants were the cultivar LCP 82-89, five were the cultivar CP 74-383, and one was the cultivar CP 65-357. Leaves and side shoots were removed and the stalk surfaces were cleaned with soap and rinsed with tap water. The clipper was cleaned between each internode by rinsing thoroughly with tap water. Vascular sap samples were collected from all internodes including the basal, soil-level internode to the last elongating internode having a length of at least 1 cm. For most internodes, sap was expelled into microfuge tubes by forcing air through excised internodes with a small, electric air pump. For internodes that would not release sap by this method, a 1-cm long core of tissue (8 mm diameter) was centrifuged at 3,400 x g for 5 min. The total number of internodes assayed per stalk ranged from 17 to 25. Numbering of internodes was from the base to the apex position. The internodes of each stalk were grouped by position: those in the lower one third, the middle one third, and upper one third.

Isolation on semi-selective medium (Davis et.al., 1994) and PCR (Pan et.al., 1997) were used to assay the sap samples for *X. albilineans*. For isolation, about 5 µl of undiluted sap per internode was streaked on the agar medium and incubated at 28 C for 4 to 5 d. Each culture was visually inspected by two investigators. For PCR, a 200 µl aliquot from each sap sample was centrifuged at 3,400 x g for 10 min. The resulting pellet was washed twice with sterile water, resuspended in about 30 µl sterile water, and 1 µl of the suspension was used in the assay following the procedure of Pan et al. (1997). PCR also was used to identify *X. albilineans* when the two investigators were unable to agree on the identity of colonies. Portions of the bacterial colonies in question were included in the amplification reactions.

The percent of internodes infected with *X. albilineans* (PCT) was determined for each position group. A new set of data (ASPCT) was created using an inverse sine transformation program (SAS, 1990). Since arsin transformation did not significantly reduce coefficient of variability, only PCT data were used in the analysis of variance of *X. albilineans* detection using the general linear models procedure of SAS program (1990). Sources of variation were sample type (symptomatic vs. asymptomatic) (1 df), method (PCR or isolation) (1 df), and position (upper, middle, and lower) within sample type (4 df).

RESULTS

Xanthomonas albilineans was detected in most internodes from the middle (97%) and lower (99%) thirds of the 11 symptomatic stalks by both PCR and isolation on semi-selective medium methods, while about 70% of the internodes from the upper third tested positive (Table 1, Fig. 1). Of 233 sap samples from the symptomatic stalks tested by PCR, 204 (88%) were positive and 29 (12%) negative for the presence of *X. albilineans*. Conversely, *X. albilineans* was isolated on the semi-selective medium from 211 (91%) of the 233 sap samples from the symptomatic stalks. The leaf scald bacterium was not detected on the remaining 22 plates (9%). The number of *X. albilineans* colonies was too numerous to count on 192 (82%) of the plates streaked with sap samples from the symptomatic stalks. Only 19 plates (8%) had less than 100 *X. albilineans* colonies per plate. While 198 sap samples tested positive by both PCR and isolation, 7 tested positive only by PCR but not by isolation and 13 tested positive only by isolation but not by PCR. Colonies of *X. albilineans* from the 13 isolation plates were confirmed by PCR.

The distribution of *X. albilineans* did not follow a consistent pattern among internodes of the asymptomatic stalks, and the number of infected internodes varied among the asymptomatic stalks (Table 1, Fig. 2). Of 229 sap samples from the asymptomatic stalks tested by PCR, 84 (37%) were positive and 145 (63%) negative for the presence of *X. albilineans*. By isolation on the semi-selective medium, 63 (28%) of the sap samples were found to be infected with *X. albilineans*. Eighty-one plates (35%) had colonies of other bacteria only, and 85 plates (37%) had no colonies at all. The number of *X. albilineans* colonies per plate was greater than 100 on 22 plates, less than 10 on 21 plates, and between 10 to 100 on 20 plates. While 41 sap samples tested positive by both PCR and isolation, 43 tested positive only by PCR but not by isolation; and 22 tested positive only by isolation but not by PCR. The *X. albilineans* colonies from the 22 isolation plates were also confirmed by PCR.

The percent of internodes in which *X. albilineans* was detected is shown in Table 1. There was no significant difference in mean percentage of detection by diagnostic method; therefore, data were pooled across diagnostic methods. In symptomatic stalks, mean percent infected internodes was significantly higher for the middle (97%) and lower (99%) third of internodes than for the upper third (70%). Mean percent infected internodes was significantly higher for all the three portions of symptomatic stalks than for the three thirds of asymptomatic stalks. However, mean percent infected internodes among these three portions of asymptomatic stalks (upper = 26%; middle = 33%; upper = 39%) did not differ significantly.

Several unidentified bacterial species were isolated from asymptomatic stalks. Although many colonies were morphologically (e.g., size, shape, color, and texture), distinct from the *X. albilineans* colonies, at least one produced colonies that looked very similar. This led to a difference in identification of 76 of the 462 plates (16.5%) between the two investigators. All 76 plates were streaked with sap from asymptomatic stalks and each had low numbers of colonies of mixed morphology, an indication of low bacterial population. Of 42 isolates thought to be *X. albilineans* by one investigator but not by the other, 41 were confirmed by PCR. Of the other 34 isolates thought to be a bacterium other than *X. albilineans* by one investigator, only four produced the *X. albilineans*-specific PCR product.

DISCUSSION

The management of leaf scald disease is often complicated by latent expression of infection. Disease symptoms may not develop in infected sugarcane plants unless the bacterium reaches a high titer or the plants undergo water stress (Ricaud and Ryan, 1989). Efficient detection of *X. albilineans* in infected, asymptomatic stalks is needed to prevent these stalks from being used as seed cane, thereby reducing further spread of the disease and possible loss of yield. Achieving this goal requires not only a reliable assay technique, but a proper sampling procedure as well. Since *X. albilineans* is xylem-limited, expressed sap from stalks should be the primary material used for testing.

In previous studies (Comstock and Irey, 1992; Rott e.at., 1994), researchers did not agree on which section of the stalk would provide the highest probability of detecting *X. albilineans* in asymptomatic stalks. Unlike the previous studies, we examined sap samples from every elongated internode with a length of at least 1 cm. Detection of *X. albilineans* infection was random among the three sections (upper, middle, and lower thirds) of infected but asymptomatic stalks (Table 1). Our conclusion, therefore, is that targeting a certain section of the stalk for sampling among asymptomatic stalks does not increase the probability of detecting *X. albilineans* infection, and may lead to an underestimate of the level of infection. We recommend that in the assessment of leaf scald infection in a field where no disease symptoms exist, a mixture of sap samples from six internodes per stalk, two randomly from each section, be prepared for testing. Although 20 stalks may be collected across one entire field, further study is needed to determine the minimum number of stalks that should be sampled from asymptomatic fields.

In contrast, *X. albilineans* was detected in almost every internode in the lower and middle thirds, but in only 70% of the internodes in upper third, of symptomatic stalks (Table 1, Fig. 1). The failure to detect *X. albilineans* by either PCR or isolation on semi-selective medium method from many of the apical internodes in this study is in contrast to the results of Rott et al. (1994) who found culturable populations of *X. albilineans* in apices. This is probably the result of a difference in methodology. Rott et al. homogenized the tissue, whereas we used positive air pressure or centrifugation to obtain sap samples from vascular bundles. It appears that extracting the content of the vascular bundles by positive pressure or centrifugation from the apical tissue is not as effective as from further down the stalk. Thus, homogenization may be a more efficient means to obtain detectable populations from the upper internodes.

The PCR protocol (Pan et.al., 1997) was used in this study because of its greater specificity and quick turn-around (Rott et.al., 1986). Nonetheless, PCR was vulnerable to unknown inhibitors present in some sap samples (Rott et.al., 1986). To compensate for this problem, we also used the isolation on semi-selective medium method (Davis et.al., 1994) which showed a greater sensitivity in detecting *X. albilineans* than serological methods (Comstock and Irey, 1992; Davis et.al., 1994). In the present study, 80% of the results matched between the two methods. However, *X. albilineans* was detected in 50 internodes (10%) by PCR only and in other 35 internodes (8%) by isolation only. Colonies of *X. albilineans* from these 35 isolation plates also were confirmed by PCR. We believe that these mismatches were due to a greater sensitivity of PCR detection on one hand and vulnerability of PCR to inhibitors on the other (Pan et.al., 1997). It is noteworthy that the mismatches occurred for sap samples collected from all three portions of asymptomatic stalks.

Unlike the sap from symptomatic stalk, where large populations of *X. albilineans* were present, much lower populations of the bacterium were observed in sap samples from asymptomatic stalks. A similar correlation between bacterial populations and leaf scald disease severity was observed by Rott et al. (1994). They found the presence of leaf scald symptoms was related to large *X. albilineans* populations, while few or no symptoms were related to low or undetectable levels of *X. albilineans*. In asymptomatic stalks, several bacterial species were commonly present in sap samples which may have interfered with detection of *X. albilineans* on a semi-selective medium.

Polymerase chain reaction also was used to help distinguish *X. albilineans* from unknown bacteria on semi-selective plates. Unlike the colonies from several other bacterial species that exhibited distinct morphological characteristics, colony morphology of at least one bacterial species was almost identical to that of *X. albilineans* on the semi-selective medium. This situation occurred in 16.5% of the samples and was resolved on the basis of whether they produced the *X. albilineans*-specific DNA product by PCR.

ACKNOWLEDGMENTS

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Table 1. Mean percentage of internodes in which *Xanthomonas albilineans* was detected among the upper, middle, and lower thirds of sugarcane stalks[1].

	Symptomatic	Asymptomatic
Upper	70 a	26 c
Middle	97 b	33 c
Lower	99 b	39 c

[1] Means followed by the same letter were not significantly different at P = 0.05.

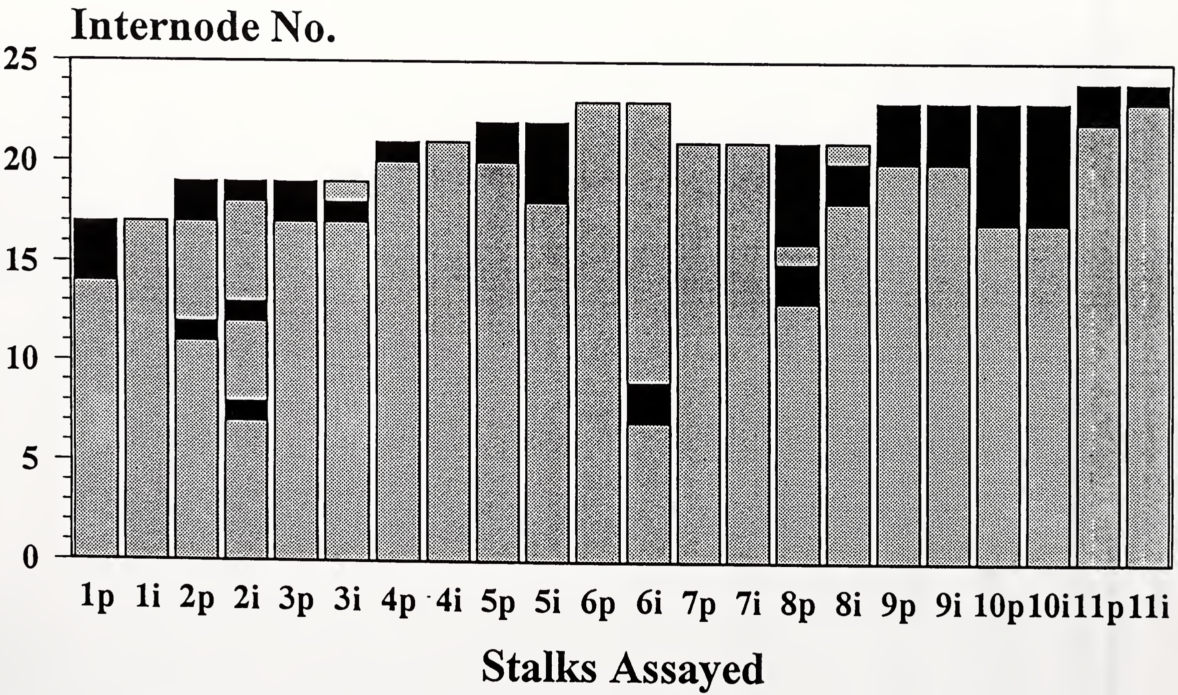

Figure 1. Detection of *Xanthomonas albilineans* in internodes of symptomatic sugarcane stalks from three cultivars by PCR (p) or by isolation (i) on semi-selective medium. Stalks 1 to 5 were cultivar LCP 82-89, 6 to 10 were cultivar CP 74-383, and 11 was cultivar CP 65-357. Solid areas indicate internodes where *X. albilineans* was not detected; stippled areas indicate internodes where *X. albilineans* was detected.

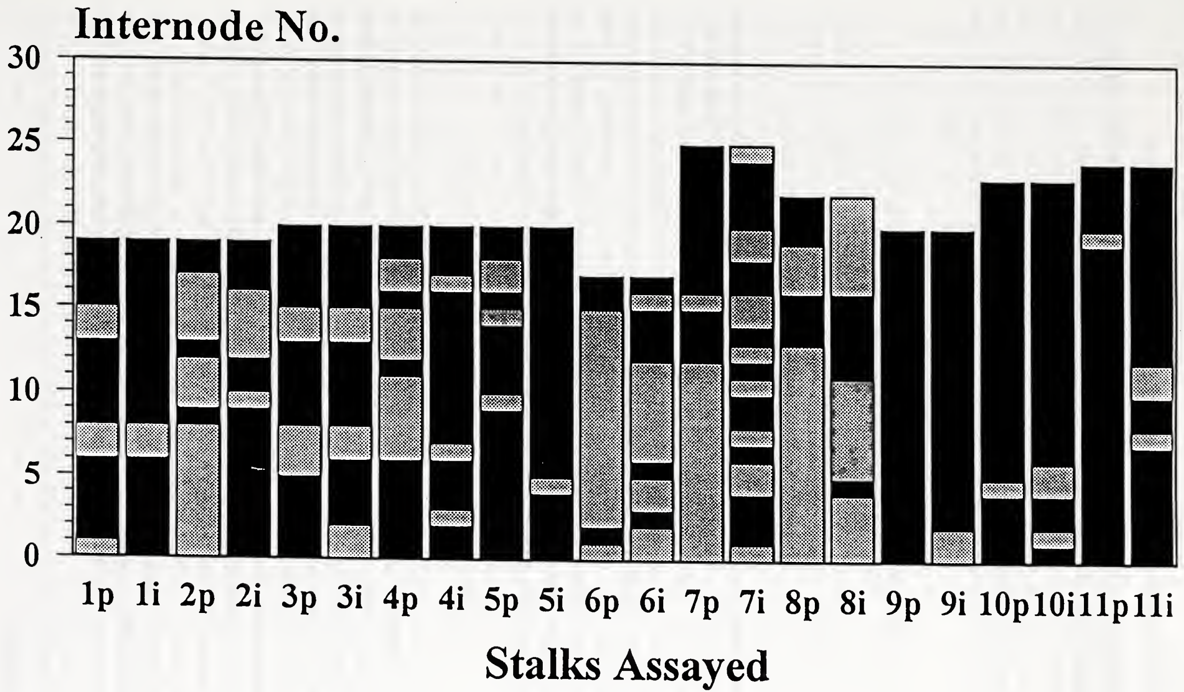

Figure 2. Detection of *Xanthomonas albilineans* in internodes of asymptomatic sugarcane stalks from three cultivars, collected from the same stool of the symptomatic stalk, by PCR (p) or by isolation (i) on semi-selective medium. Stalks 1 to 5 were cultivar LCP 82-89, 6 to 10 were cultivar CP 74-383, and 11 was cultivar CP 65-357. Solid areas indicate internodes where *X. albilineans* was not detected; stippled areas indicates internodes where *X. albilineans* was detected.

EFFECT OF FLOODING ON EFFICACY OF SOIL INSECTICIDES USED FOR WIREWORM CONTROL IN FLORIDA SUGARCANE

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ABSTRACT

The two soil insecticides most commonly used for wireworm control in Florida sugarcane are ethoprop applied as Mocap 20-G and phorate applied as Thimet 20-G. The objective of our research was to determine if the efficacy of these insecticides against the wireworm, *Melanotus communis*, is reduced after flooding since flooding due to excessive rainfall does occur in Florida sugarcane fields. Laboratory tests were conducted from 1996 to 1998. On a per volume basis of moist soil, seven times as much ethoprop or phorate was necessary to kill similar numbers of *M. communis* in muck versus sandy soil. Both insecticides retained efficacy against the wireworms, even after a seven day flood. At the rates used in our study, our data also showed that phorate killed more *M. communis* than ethoprop when granular formulations of these insecticides were used at equal rates.

INTRODUCTION

Wireworms are important insect pests of Florida sugarcane. These insects attack the underground portions of the plant by feeding on the buds and root primordia during germination and on shoots and roots after germination. Wireworms are primarily a pest in newly planted sugarcane although the insects are also ubiquitous in ratoon sugarcane. Of the different wireworm species found in Florida sugarcane, *Melanotus communis* is the most important pest. Damage by this wireworm has been thoroughly documented in studies by Hall (1985; 1990). Cherry and Hall (1986) reported on the flight activity of *M. communis* in Florida sugarcane and Cherry (1988) noted the distribution and abundance of the species in Florida sugarcane.

To prevent wireworm damage, soil insecticides are routinely applied in the furrow with seedpieces at planting in Florida sugarcane. Wireworms were controlled in plant cane during the 1950's by spraying the seedpieces in the open furrow at planting with heptachlor, chlordane, or aldrin

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(Breggar et al. 1959). Gifford (1964) reported on insecticide tests for wireworm control during the early 1960's. The effect of some soil insecticides on sugarcane yield in Florida was reported by Samol and Johnson (1973). Hall and Cherry (1985) noted the contact toxicities of various insecticides to the wireworm *M. communis*. The comparative toxicities of fonofos and phorate to different populations of *M. communis* in southern Florida were reported by Jannson et al. (1988). Most recently, Coale and Sosa (1991) evaluated sugarcane yield response to soil insecticides in Florida sugarcane fields.

In spite of the previous studies, there is little understanding of how soil insecticides actually work for wireworm control in Florida sugarcane fields. Currently, the two soil insecticides most commonly used for wireworm control in Florida sugarcane are ethoprop applied as Mocap 20-G and phorate applied as Thimet 20-G. Occasionally, newly planted sugarcane fields are flooded by excessive rainfall. The efficacy of the two soil insecticides against wireworms following flooding is unknown and of interest to growers. The objective of our research was to determine if the efficacy of these insecticides against *M. communis* is reduced after flooding. Associated data on the efficacy of these insecticides in sand versus muck are also given.

MATERIALS AND METHODS

Preliminary tests were conducted during 1996 to determine mortality of *M. communis* wireworms (larvae) exposed to ethoprop and phorate at different rates and times in sand and muck soils. These data were essential to select the proper dosage and exposure time to be used in later flood tests. Too much or too little insecticide would hinder comparisons between flood regimes and insecticides. Hence, we desired to select the proper dosages of insecticides to produce intermediate mortality where differences in flooding treatments and insecticide efficacy could best be observed. By intermediate mortality, we mean mortality in the range of 60% to 90% caused by an insecticide dosage in moist soil over a given time. Wireworms were field collected from commercial sugarcane fields in Florida. After collection, the wireworms were stored in a laboratory in plastic pans with soil and raw carrots for food. The sandy soil (Riviera Sand) and muck soil (Pahokee Muck) used in all tests came from commercial sugarcane fields in Palm Beach County, Florida. The muck soil and sandy soil were 73.9% and 3.3% organic matter respectively as determined by soil analysis conducted at the Everglades Research and Education Center, in Belle Glade, Florida. Soil moisture may be a factor in insecticide efficacy (Harris 1972). Hence, soil moisture was controlled in our tests by using air-dried soil and adding a known quantity of water to produce moist soils. Previous to insecticide tests, soil was passed through a U.S.A. Standard #4 Sieve with 4.75 mm opening and air-dried for a minimum of two weeks in large pans. The effect of insect weight on pesticide response is complex and Robertson and Preisler (1991) should be read for a discussion of this matter. However, since insect weight may be a factor in insecticide efficacy (Robertson and Preisler 1991), only wireworms within the range of 0.05 to 0.10 g per wireworm were used. Wireworms within this range were thereafter selected to make sure that wireworm weights did not vary significantly between treatments. The overall mean of all wireworms used in all tests was 0.07 g per wireworm.

within the range of 0.05 to 0.10 g per wireworm were used. Wireworms within this range were thereafter selected to make sure that wireworm weights did not vary significantly between treatments. The overall mean of all wireworms used in all tests was 0.07 g per wireworm.

Preliminary tests were conducted during January and February 1996. Air-dried soil was placed into clear plastic pans (17 X 12 X 7 cm high) and water added and stirred in to produce a moist soil. The moist muck soil used in each pan was prepared from 250 g air-dried muck plus 150 g(ml) of water. The moist sand used in each pan was prepared from 500 g air-dried sand plus 30 g (ml) of water. Thereafter, a wide range of insecticide doses of commercial granular formulations (20 G) of ethoprop and phorate were added and stirred into the pans. Next, five pieces of raw carrot (each piece approximatley 1 cm^3) were pushed into the soil of each pan to serve as a food source. Last, ten wireworms were placed into each pan, a lid put on the pan, and pans stored at room temperature (approximately 23 °C) in a laboratory. Wireworm survival was measured once every 7 days for 28 days by opening pans, sorting through soil for live wireworms, and then putting the soil and wireworms back into the pan. Survival was measured as wireworm movement, including moving when prodded. Data from the preliminary tests showed that 0.1 g of 20G of ethoprop or phorate in muck in a pan with wireworm survival measured after 14 days produced the intermediate mortality desired for further, more extensive testing in the flood tests. Data from preliminary tests also showed that a rate of 0.01 g of 20G of ethoprop or phorate in the sandy soil in a pan with wireworm survival measured after 14 days produced the intermediate mortality desired for further, more extensive testing in the flood tests. Moist soil in the pans was 3.5 cm deep in the muck soil and 2.5 cm deep in the sandy soil. If converted to a per volume basis of moist soil in the pans, seven times as much ethoprop or phorate was necessary to kill comparable numbers of wireworms in the muck versus sand.

Flooding tests were conducted to simulate a field flooded for different time intervals. Tests were conducted from March 1996 through March, 1998. To ensure freshness, new 20-G commercial formulations of both insecticides were obtained in October, 1997 for the three and seven-day flood tests. Tests used the same pans as the previous test except pans to be flooded had about 150 small holes in the pan bottom. These holes were small enough to retain wireworms, but allowed water to flow into and out of the pans. Insecticide rates were noted earlier. At the beginning of each test, six pans were filled with soil and insecticide added as described in the previous test. All six pans contained one soil type. Two pans were controls (no insecticide) and the other four pans had ethoprop and phorate at equal rates. Thereafter, three pans (one control, one phorate treatment, one ethoprop treatment) to be flooded were put into three larger plastic pans. Water was added until the water level was about 5 mm from the top of the small plastic pan. The six pans (3 unflooded + 3 flooded) in each test were then held for 1 day (24 h) or 3 days (72 h) at room temperature. An additional test was made using a seven day (168 h) flood using only flooded soils (control + two insecticides) since unflooded comparisons of the two insecticides had already been conducted in both the one and three-day flood tests. Flood pans were removed from the large pans and water allowed to drain for 24 hours. Calculations based on weight changes in the pans showed that approximately 75% and 84% of the water in flooded pans drained out of the muck and sandy soils respectively after this 24-h period. After drainage, carrots and wireworms were added as described in previous tests.

Flood pans were stored on paper towels and all pans kept in a laboratory at room temperature. Wireworm survival was recorded after 14 days. This test was replicated five times in each of the two soils at each of the three flood durations. Mean survival of the wireworms in each of the soil types at each flood duration was analyzed using Tukey's test (SAS Institute 1996).

RESULTS AND DISCUSSION

Mean survival of *M. communis* in muck and sand soils previously flooded for one day is shown in Table 1. The mean survival of the wireworms was not significantly different in both insecticide treatments in both soil types before versus after the flood. These data show that the one-day flood did not significantly reduce the efficacy of the insecticides against the wireworms. Wireworm survival was significantly lower in phorate versus ethoprop in the unflooded muck test. There were no significant differences in wireworm survival between phorate and ethoprop in the three other direct comparisons possible (i.e. same soil type and same flood condition).

Mean survival of *M. communis* in soils previously flooded for three days is also shown in Table 1. The mean survival of the wireworms was not significantly different in both insecticide treatments in both soil types before versus after the flood. These data show that the three-day flood did not significantly reduce the efficacy of the insecticides against the wireworms. Wireworm survival was significantly lower in phorate versus ethoprop in the unflooded and flood tests in the sandy soil. There were no significant differences in wireworm survival between phorate and ethoprop in the unflooded and flooded muck tests.

Mean survival of *M. communis* in soils previously flooded for seven days is shown in Table 1. Wireworm survival was significantly higher in controls than muck or sand containing phorate or ethoprop flooded for seven days. These data show that both insecticides retained efficacy against the wireworms even after a seven-day flood. Wireworm survival was significantly lower in the phorate versus ethoprop treatments in both soil types flooded for seven days.

In summary, our data show the following. First, on a per volume basis of moist soils, seven times as much ethoprop or phorate was necessary to kill similar numbers of *M. communis* in muck versus sandy soil. Our data are consistent with Harris (1972) who noted that soil type has a major influence on soil insecticide efficacy. Harris (1972) also provides numerous examples of increasing organic content of a soil decreasing soil insecticide efficacy as we observed in our study. In Florida, sugarcane is grown on soils ranging from highly organic muck to low organic sandy soils. It is probable that reduced rates of soil insecticides could be used for *M. communis* control in sandier soils. Our data also showed that both ethoprop and phorate retained efficacy against the wireworms even after a seven-day flood. And lastly, it should be noted that 10 direct comparisons (same soil type and flood regime) are possible in Table 1 in which the efficacy of ethoprop versus phorate may be compared. In five of these comparisons, phorate killed significantly more *M. communis* than an equal rate of ethoprop. Ethoprop did not kill significantly more *M. communis* than phorate in any test. The only previously published study comparing efficacy of the granular formulations (20G) of ethoprop versus phorate against wireworms in Florida sugarcane fields was published by Coale and Sosa (1991). Consistent with our laboratory data, they reported in their field study that wireworm populations were lower in the phorate treatment than the ethoprop treatment when both insecticides were compared at equal rates.

Mention of a pesticide or product does not constitute an endorsement or recommendation by the University of Florida.

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Table 1. **Mean[a] survival of *M. communis* in soils previously flooded for one, three, or seven days.**

	One-day flood					
	Unflooded			Flooded		
	Control	Phorate	Ethoprop	Control	Phorate	Ethoprop
Muck[b]	9.8 a	1.4 c	3.6 b	9.2 a	2.8 bc	2.6 bc
Sand[b]	9.0 a	1.8 b	2.8 b	9.4 a	2.2 b	2.4 b

	Three-day flood					
	Unflooded			Flooded		
	Control	Phorate	Ethoprop	Control	Phorate	Ethoprop
Muck[b]	10.0 a	1.6 b	2.6 b	9.8 a	2.8 b	3.2 b
Sand[b]	10.0 a	1.0 c	4.4 b	9.8 a	0.8 c	3.8 b

	Seven-day flood					
	Unflooded[c]			Flooded		
	Control	Phorate	Ethoprop	Control	Phorate	Ethoprop
Muck[b]	-	-	-	8.8 a	0.8 c	4.4 b
Sand[b]	-	-	-	9.2 a	1.6 c	5.0 b

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[a] Means in a row followed by the same letter are not significantly different (alpha=0.05) using Tukey's test (SAS Institute 1996).

[b] 10 wireworms/pan at start. 0.10 g or 0.01 g of 20G of an insecticide added to muck and sand in each pan respectively.

[c] Not tested.

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USE OF A NITROGEN STABILIZATION PACKAGE TO[1] INCREASE YIELDS AND REDUCE THE NITROGEN REQUIREMENTS OF SUGARCANE

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ABSTRACT

A study was initiated to determine the effect of a nitrogen stabilization package (N-hib Ca, composed of calcium chloride, magnesium chloride, and a urease inhibitor) and liquid urea, on yields and nitrogen fertilizer requirements of sugarcane *Saccharum spp*. hybrids. Urea and the nitrogen stabilization package were applied in all possible combinations in a 4x3 factorial (N rates were 0, 67, 134, and 201 kg N/ha; and calcium rates from the N stabilization package were 0, 22, and 44 kg Ca/ha) to a Baldwin silty clay (thermic vertic Ochraqualf) soil for four years. Adding 44 kg Ca/ha as N-hib Ca to 134 kg N/ha increased sugar yields by 2,950 kg/ha ($1531/ha at a sugar price of $0.519/kg) across the four year study, and reduced the nitrogen fertilizer requirement (by 67 kg N/ha each year) needed to obtain maximum yields. Use of N-hib Ca in a liquid urea fertilization program could, therefore, increase sugarcane yields and reduce environmental degradation resulting from nitrogen fertilization.

INTRODUCTION

Sugarcane production in Louisiana is limited by the deterioration in stubble crop yields, which results in the expensive practice of replanting every third or fourth year. Stubble crops also require higher fertilizer rates than plant cane, while producing less sugar/ha. The decrease in cane yields and increased fertilizer needs of stubble crops are partially related to disease in the sugarcane root system. Since calcium is associated with strong cell walls, which are important in maintaining the health of the root system and in resisting attack by pathogens, increasing Ca in a soil fertility program could possibly result in increased crop yields and improved fertilizer use efficiency.

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[1] Research was partially supported by Stoller Enterprises, Inc. N-hib Ca is a product of Stoller Enterprises, Inc. Use of N-hib Ca in this study should not be interpreted as an endorsement of this product.

The Ca and Mg contents of sugarcane and soils in Louisiana are thought to be substantially in excess of minimum amounts considered nutritionally necessary for good cane growth (Golden, 1971). Ricaud and Arceneaux (1988), however, obtained a sugarcane yield response to 5 and 10 T/A of gypsum, but not at 1T/A. Consequently, their response could not be explained by S deficiency, and may, therefore, have been caused by Ca, or soil flocculation resulting from the high rates of Ca addition.

Research has demonstrated the positive effects of an enhanced ammonium supply (EAS) on plant growth (Camberato and Bock, 1989, 1990a; Heberer and Below, 1989). Provision of an EAS increased tillering and plant and grain dry matter of wheat *Triticum aestivum* L. in solution culture (Heberer and Below, 1989) and greenhouse soil media (Bock, 1987; Camberato and Bock, 1990 a,b). Growth responses to an EAS in the field, however, have been inconsistent (Spratt and Gasser, 1970; Bock et al. 1991; Pan et al., 1992), implying that other factors may be limiting response to EAS.

Limited growth responses to EAS in field environments may be related to availability of ammonium or other nutrients. Research shows that adding supplemental Ca, as calcium chloride, to ammonium in a soil fertility program resulted in greater growth and N absorption by northern bean *Phaseolus vulgaris* L.; (Fenn et al., 1987), radish *Raphanus sativus* L.; (Fenn and Taylor, 1990), and beet *Beta vulgaris* L.,(Fenn et al., 1994) than ammonium alone. Also, work with vegetable (Fenn and Taylor 1990; Fenn et al. , 1991; Fenn et al. , 1994; Fenn et al. , 1987) and grain crops (Fenn et al. , 1995) showed that combining calcium chloride with liquid urea in a soil fertilization program increased crop yields and nitrogen use efficiency. Camberato and Bock (1989, 1990 a,b) used soil preincubation with calcium carbonate in greenhouse studies and observed positive grain yield responses to an EAS with sorghum *Sorghum bicolor* L. and wheat, while Spratt and Gasser (1970) did not apply Ca, and observed no grain yield response to EAS with wheat grown in the field. This suggests that Ca availability may influence the response to an EAS, and that supplemental Ca may be required to obtain this response.

Calcium promotion of ammonium nutrition has been attributed to a physiological role in enhancing ammonium absorption (Fenn et al., 1987; Fenn and Taylor, 1990). An additional role of Ca may be to displace ammonium from soil exchange sites. Calcium has a higher affinity for exchange sites than ammonium (Nommik and Vahtras, 1982) due to the higher ionic charge/radius ratio of Ca (Thompson and Troeh, 1978). Therefore, the application of both ions together should reduce ammonium adsorption, resulting in higher concentrations of ammonium in the soil solution, thereby, increasing ammonium-N availability to plants. Koenig and Pan (1996a) found that adding calcium chloride to ammonium-N fertilizer increased ammonium concentrations in the soil solution by 167%, and attributed it to the preferential adsorption of Ca and the displacement of ammonium from soil exchange sites.

There is some evidence that Cl may also increase wheat yields with an EAS. Higher winter wheat yields with ammonium chloride than with ammonium sulfate fertilization were attributed to lower leaf osmotic potentials (Christensen et al., 1981) or delayed nitrification in the soil (Christensen and Brett, 1985), resulting in inhibition of take-all *Gaeumannomyces graminis* root rot. Koenig and Pan (1966b) conducted greenhouse experiments with wheat to determine if Ca or Cl promote wheat response to an EAS and concluded that the yield response to calcium chloride was due to chloride rather than the added Ca. They also found that chloride stimulated Ca uptake, which may have played a secondary role in the EAS response.

The objective of our study was to determine whether using a nitrogen stabilization package (N-hib Ca) in a liquid urea soil fertility program can increase sugarcane yields, and decrease nitrogen fertilizer requirements.

MATERIALS AND METHODS

In October 1990, a urea (0, 67, 134, and 201 kg N/ha) by N-hib Ca (0, 22, and 44 kg Ca/ha) soil fertility study (12 treatments in all possible combinations) was initiated at the Iberia Research Station on a Baldwin silty clay (thermic Vertic Ochraqualf) soil. Initial soil analyses showed 279, 36, 281, 3396, and 668 ppm, respectively, for P, Na, K, Ca, and Mg; soil pH was 5.2. Experimental treatments (Table 1) were replicated three times in a randomized complete block design, and plots consisted of three 1.8m by 14.6m rows, separated by 2.4m alleys at the end of each plot.

In late-October 1990, second progeny Kleentek variety CP65-357 was planted at three stalks and a lap of two joints. In late-April or early-May of 1991, 1992, 1993, and 1994 a liquid fertilizer solution containing urea and (or) N-hib Ca (composed of calcium chloride, 10% Ca; magnesium chloride, 1.5% Mg; and a urease inhibitor) was added to the inside of each row in the study at the N and Ca rates in Table 1. Phosphorus, K, and S were blanket applied to the outside of all rows at 101 kg P_20_5 /ha (as polyphosphate), 135 kg K_20/ha (as muriate of potash), and 25 kg S/ha (as gypsum). The rows were hilled to cover the fertilizer, and cane was grown through harvest using standard cultural practices.

In September of 1991, 1993, and 1994 sugarcane stalks in all plots were counted (stalk counts were not made in 1992 because of damage from Hurricane Andrew) to determine the effects of the treatments on plant population. All experimental plots were harvested each of the four years and weighed. A 10-stalk sample was taken from each plot each year at harvest to determine average stalk weight and to calculate commercially recoverable sugar (CRS) per ton of harvested cane.

Statistical analyses were performed using the Statistical Analysis System (SAS, 1985) with the twelve N by Ca fertilizer treatments as main-plots, and years as sub-plots. Protected LSD values ($P \leq 0.10$) were calculated from the main-plot error for determining the effect of the fertilizer treatments on the measured yield parameters.

RESULTS AND DISCUSSION

Comparison of T #9 with T #7 (Table 1) shows that adding 44 kg Ca/ha as N-hib Ca to 134 kg N/ha increased cane tonnage across the four years by 27.3 t/ha. Increasing N from 134 to 201 kg/ha in the absence of Ca (T #7 vs. T #10) increased total tonnage by 28.6 t/ha. Consequently, 44 kg Ca/ha increased cane yields as much as an additional 67 kg N/ha, and reduced sugarcane nitrogen requirements from 201 kg/ha to 134 kg/ha.

Sugar yield across the four years rose (Table 2) as N rates were increased in the absence of N-hib Ca (T #1 vs. T #4; T #4 vs. T #7; and T #7 vs. T #10). However, where Ca was added at either 22 or 44 kg/ha, there was no additional ($P \leq 0.10$) yield response to N beyond the 134 kg N rate.

Likewise, adding N-hib Ca to the 0, 67, and 201 kg N/ha treatments did not significantly ($P \leq 0.10$) increase sugar yields. However, adding 44 kg Ca/ha to 134 kg N/ha (T #9 vs. T #7) did increase total sugar yields by 2,950 kg/ha (11.6%), which is the statistically equivalent response (2,260 kg/ha, 8.9%) obtained from increasing N from 134 to 201 kg/ha in the absence of Ca (T #7 vs. T #10). This increase in sugar yield (Table 2) was related to increased cane tonnage (Table 1).

N-hib Ca (44 kg Ca/ha) increased ($P \leq 0.10$) average stalk weights (Table 3, T #9 vs. T #7) across harvest years only at the 134 kg N/ha fertilizer rate (which was largely responsible for the difference in total cane tonnage for T #9 vs. T #7 in Table 1). Nitrogen fertilizer increased ($P \leq 0.10$) average plant population across harvest years (T #'s 4, 5, and 6 vs. T #'s 1, 2, and 3; and T #11 vs. T #5), while N-hib Ca did not. Fertilizer treatments did not significantly ($P \leq 0.10$) affect CRS values in our study (Table 3).

The yield response from addition of the nitrogen stabilization package to liquid urea (Table 2, T #9 vs. T #7) supports previous research showing that adding calcium chloride to an EAS of nitrogen increased crop yields (Fenn et al., 1995; Fenn and Taylor, 1990; Fenn et al., 1991; Fenn et al., 1994; Fenn et al., 1987). However, the yield response to calcium chloride in our study (11.6%) was not nearly as large as that obtained for radish (66%, Fenn and Taylor, 1990), onion *Allium cepa* L. (64%, Fenn et al., 1991), and beet (26%, Fenn et al., 1994).

Since the calcium source used in our study (N-hib Ca) also contained magnesium chloride and a urease inhibitor, we cannot say that the sugar yield response obtained with N-hib Ca (Table 2, T #9 vs. T #7) was solely caused by the addition of calcium chloride to the liquid urea fertilizer program. However, it appears that this yield response was not caused by the urease inhibitor since addition of N-hib Ca at the 67kg N/ha rate (Table 2, T #6 vs. T #4) did not affect total sugar yields.

We also cannot say whether the yield response to N-hib Ca was caused by decreased root disease, higher concentrations of ammonium in soil solution, or improved nutrient uptake. However, we can say that the nitrogen stabilization package did increase sugar yields through increased cane tonnage (caused by heavier stalk weights) and that it reduced the amount of nitrogen needed to obtain maximum yields. This indicates that the N stabilization package improved the plants' efficiency in taking up N. Further work is needed to determine the reason for sugarcane response to N-hib Ca.

CONCLUSIONS

Our results show that using a nitrogen stabilization package (N-hib Ca) in a liquid urea fertilization program resulted in increased sugar yields (2,950 kg/ha across four years) and more efficient utilization of nitrogen fertilizer. This reduces the potential for nitrogen to pollute the environment and increased gross profits (at $0.519/kg of sugar) by $1531.30/ha across the four years. Our data suggest that it could be profitable for producers to use N-hib Ca in a liquid urea fertilization program if it is competitively priced.

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Table 1. Effect of urea and N-hib Ca on sugarcane tonnage across four years.

			Harvest years				
T#	N	Ca	1991	1992	1993	1994	Total
	- - kg/ha - -		- - - - - - - - - - - - - - - - - t/ha - - - - - - - - - - - - - - - - -				
1	0	0	69.3	44.2	47.8	39.0	200.3
2	0	22	71.7	44.4	48.7	39.5	204.3
3	0	44	70.6	43.9	46.9	39.2	200.6
4	67	0	82.7	48.2	65.2	56.1	252.2
5	67	22	78.7	52.0	65.7	50.4	246.8
6	67	44	74.7	52.0	64.8	52.2	243.7
7	134	0	76.7	54.7	70.2	59.2	260.8
8	134	22	84.1	54.9	67.5	63.2	269.7
9	134	44	80.7	64.8	76.5	66.1	288.1
10	201	0	87.4	59.4	76.9	65.7	289.4
11	201	22	84.7	62.8	67.7	63.9	279.1
12	201	44	84.7	70.6	74.9	65.2	295.4
LSD 0.10			10.7[†]	10.7	10.7	10.7	21.3[‡]

[†] LSD for effect of fertilizer treatments on cane tonnage within individual harvest years.
[‡] LSD for effect of fertilizer treatments on total cane tonnage for four years.

Table 2. Effect of urea and N-hib Ca on sugar yields across four years.

			Harvest years				
T#	N	Ca	1991	1992	1993	1994	Total
	- - kg/ha - - -		- - - - - - - - - - - - - - - - kg/ha - - - - - - - - - - - - - - -				
1	0	0	6190	4780	4390	3820	19,180
2	0	22	6180	4730	4350	4010	19,270
3	0	44	6180	4930	4200	4140	19,450
4	67	0	7590	5380	5900	5520	24,390
5	67	22	6420	5680	6090	4830	23,020
6	67	44	6730	5670	5830	5180	23,410
7	134	0	6970	5960	6470	5990	25,390
8	134	22	7100	6170	6330	6320	25,920
9	134	44	7140	7190	7300	6710	28,340
10	201	0	7850	6600	6940	6260	27,650
11	201	22	7490	6930	6370	6220	27,010
12	201	44	7540	8000	6820	6420	28,780
LSD 0.10			850[+]	850	850	850	1690[‡]

[+] LSD for effect of fertilizer treatments on sugar yields within individual harvest years.

[‡] LSD's for effect of fertilizer treatments on total sugar yields for four years.

Table 3. Effect of urea and N-hib Ca on average commercially recoverable sugar, stalk weights, and plant population.

T#	N	Ca	CRS	Stalk Weight	Plant population
	- - -kg/ha - -		kg/t	kg/stalk	1000/ha
1	0	0	96.5	0.83	55.8
2	0	22	96.0	0.87	56.6
3	0	44	99.0	0.85	56.6
4	67	0	98.5	0.91	65.5
5	67	22	95.5	0.94	64.0
6	67	44	97.0	0.91	63.0
7	134	0	98.5	0.88	64.0
8	134	22	98.0	0.94	67.4
9	134	44	99.0	0.97	68.7
10	201	0	96.5	0.92	68.4
11	201	22	97.5	0.93	69.7
12	201	44	98.0	0.97	65.7
LSD 0.10			NS	0.07	5.2

NS denotes that fertilizer treatments did not significantly ($P \leq 0.10$) affect commercially recoverable sugar.

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ARTICLES

MANUFACTURING

SECTION

EFFECT OF THE WEATHER ON FACTORY YIELD

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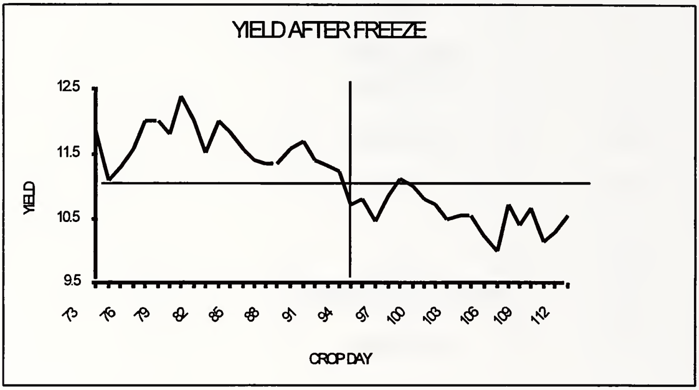
Last year, we presented our experience at Atlantic Sugar, showing how after a freeze, cane in cold lying areas had a maximum time of harvesting of 21 days, and after that, depending on prevailing temperatures, the cane began to rapidly deteriorate in the field.

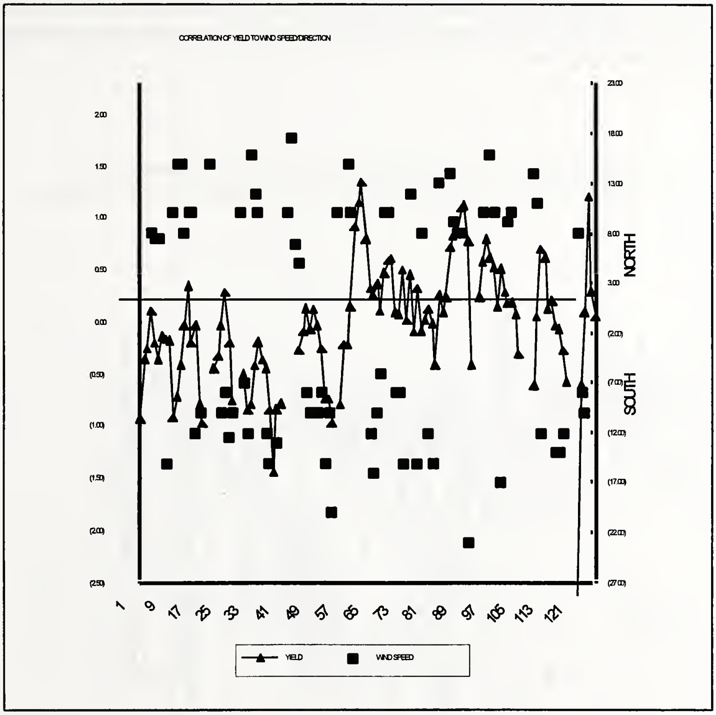


Following that general train of thought, we decided this year to do an observational study on the effects of the wind direction upon the yield at the mill. Additional motivation for this came from the often quoted tradition that "south wind drops the yield".

Meticulous records of the daily wind direction were kept, and duly posted it in what we at Florida Crystals call our Telephone Report.

It is commonly known that in the Everglades Agricultural Area, all the drainage is man made. For this reason, the sugarcane is very responsive to the field and weather conditions. Generally speaking, south wind means high temperature with also high humidity which favor fast cane deterioration, dextran formation and lower yields. On the other hand, north wind provides cool, dry air that helps cane conservation and a higher sucrose concentration of juice.

At the end of the crop, we did the following computerized graph of this information.

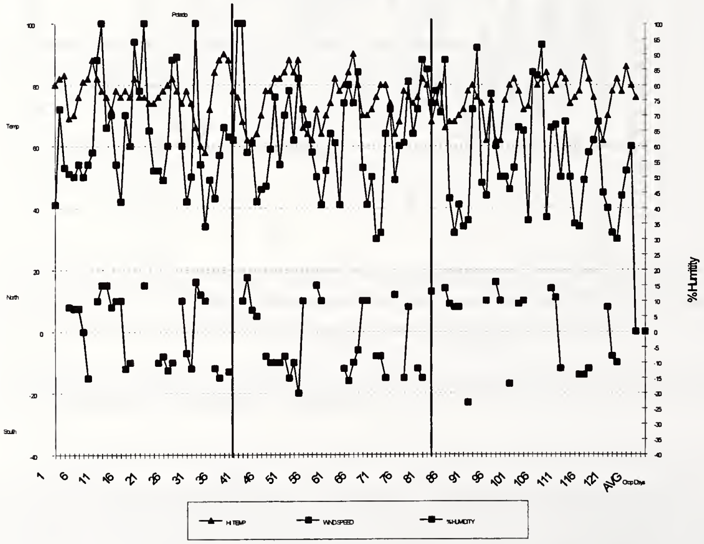


As you can see, on the right vertical axis, we plotted wind velocity from the north or south, leaving east/west as neutral on the horizontal axis. Then on the left vertical axis, we plotted the yield (plus or minus), using our final year end average of 11.10, as the horizontal base line. Our bottom horizontal line represents our days of crop.

We were very surprised to see, once the graph was plotted, how exact and true the correlation between wind direction and yield was, not only by direction, but also by intensity. As you can see, as the wind velocity increased from either the north or the south, so did the yield increase of decrease in almost exactly the same patterns. The stronger the north wind, the higher the yield, and the stronger the south wind, the lower the yield. We were surprised that such a direct correlation was present.

Since we established this truth to be self evident so clearly and exactly, we then proceeded to direct each part of the crop and to interject other factors such as: dextran levels in the crusher juice, polado treated cane as in the first third of the crop, rain, and stored cane left over from the previous day.

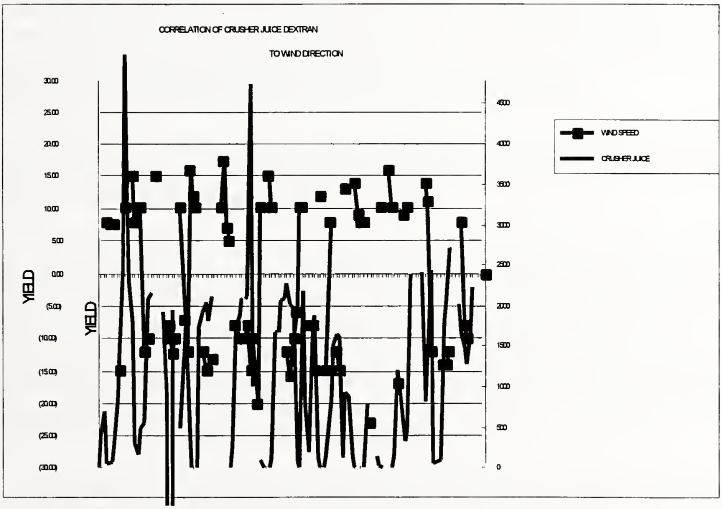
There are three distinctive crop periods on this chart marked by vertical lines:



The 1st part of the season where most of the cane had POLADO applied, the 2nd period is when artificial ripening ends, and the cane reaches maturity "naturally", and the 3rd period of the crop, where the cane has reached full maturity and flowering, with a tendency to decline. This past year, we had lot of rain in this last period.

There are other factors that cause deviations. The blank spaces on the chart represent the days we were down due to rain. Every time there was rain, and subsequently cane left in the yard, we started with a lower yield.

Other observations made are represented on the following chart:



As you can see, there was an inverse direct correlation between the wind and the dextran. In other words, the south wind plus humidity led to higher dextran and the higher (dryer) north wind, led to lower dextran.

This certainly proves the fact that weather contributes to the yield over production.

By the same token, knowing these facts must serve us, here in Florida, to better plan our harvesting practices when high humidity, rain, and/or cold are expected. We can prepare ourselves by allowing time to handle the cane which
will be more sensitive to dextran, when the wind is out of the south. Therefore, more cane should be taken to shorten burn to grind time, storage, etc. All these factors will not only have a negative impact on our yield, but probably add problems at the Fabrication Level.

With this in mind and as a closing comment, we must accept that being an agricultural business, we are in the hands of nature, not to be used as an excuse, but as a reality of our business. The best we can do is try and understand the cause and effect of different weather systems, and make whatever adjustments we can, to keep our production and efficiency levels up and maintain the best yield possible.

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NATURE, ECONOMICS, AND PROBLEM AREAS OF PURCHASING AND INSTALLING USED PROCESS EQUIPMENT

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More money is spent, as a percentage of total capital, on used machinery and equipment today than ever before. In recent years, used equipment markets have become increasingly international, growing rapidly in both developed and emerging nations. Major advantages of used equipment include pricing from roughly 20% to 70% of new replacement costs and delivery item which is a fraction of new. The four basic ways to purchase used machinery include as is, as is on approval, cleaned and tested, and rebuilt and guaranteed. The equipment is most often described in great detail, but it is critical for prospective purchasers to inspect equipment prior to placing an order. Initial appearances sometimes belie the fact that the equipment is actually in fine operating condition. At the same time, one cannot rely entirely on first impressions as it is not hard to clean and paint a machine which is essentially dysfunctional. Selling surplus equipment from ones own site is a cash generator which cleans up headaches or storage, insurance, maintenance, and property taxes. What may be obsolete in one process may not be so in another. Used equipment is not limited to individual machines, but also includes the sale and relocation of entire factories.

There is more money being spent today on used equipment than ever before in the sugar industry. This shouldn't be surprising, since saving both money and time have never been as crucial as they are in today's global marketplace.

Sugar process technology is built to last, and with regular preventive maintenance will produce for years, and can be moved from mill to mill. As a larger segment of the industry explores the used equipment market, and is becoming more familiar with both buying and selling secondhand machinery, it is becoming increasingly aware of the benefits. For instance, many firms at first turn to the used equipment market to save money. Then, they find that delivery times are so much better than traditional purchasing cycles that this soon becomes a major factor in all subsequent purchases. Similarly, Engineers and Technologists who initially buy a piece of used equipment because of the quick delivery times soon come back for the savings.

In recent years, used equipment markets have become increasingly international, especially in the face of growing demand for sugar process equipment in emerging nations. Fifteen years ago, an international order was a rarity; now used-equipment vendors in the U.S. are seeing 40-50% of the purchases coming from overseas. For the sugar industry, it is closer to 70-80%.

This document will discuss the different ways to purchase secondhand equipment including as-is, on approval, cleaned and tested and rebuilt. It will then cover many of the services that these dealers can provide including inspections, administration, financial services, specialized mechanical work and turnkey reinstallation. Finally, there will be a short discussion on the ways to maximize a mill's return on investment through the sale of its own surplus equipment.

Different ways to buy

There are four basic ways to purchase used machinery from a dealer:

- As is
- As is (on approval)
- Cleaned and tested
- Rebuilt and guaranteed

Purchasing As is

At present, about 50% of the equipment bought in North America is purchased cleaned and tested. About 20% involves rebuilt and guaranteed equipment, and 30% is sold "as is" (including that bought as is, but on approval). These percentages change rather dramatically when sales are being made from a liquidation location rather than from a dealer's own stock. When a liquidation is being held, about 75% of the equipment is sold directly from site on an as-is basis.

PRICE COMPARISON: NEW VS. USED

Equipment	New	Used As-is
10-18 tph 34° continuous centrifuge	$ 90,000	$ 20,000
Diffuser approx. 5,000 tpd capacity (tower only)	$ 2,500,000	$ 700,000
48" X 30" batch centrifuge	$ 125,000	$ 36,000
Approx. 10,000 m^2 4-effect evaporator	$ 750,000	$ 140,000
8' X 16' rotary mud vacuum filter	$ 300,000	$ 80,000

Note that the prices as described in Figure 1 above include dismantlement and preparation of secondhand equipment for transport, but do not include transport.

Purchasing equipment as-is also offers substantial savings in time of delivery compared to new equipment. Figure 2 describes relative delivery times for new and used equipment.

DELIVERY TIME COMPARISON: NEW VS. USED

Equipment	New	Used
10-18 tph 34° continuous centrifuge	14-18 weeks	1-2 weeks
Diffuser approx. 5,000 tpd capacity (tower only)	40-45 weeks	8-10 weeks
48" X 30" batch centrifuge	14-18 weeks	1-2 weeks
Approx. 10,000 m^2 4-effect evaporator	20-24 weeks	3-4 weeks
8' X 16' rotary mud vacuum filter	20-24 weeks	1-2 weeks

The used machinery dealer will describe the equipment as thoroughly as possible, and will give the purchaser all available records drawings and maintenance manuals. It is important, however to arrange an inspection of the prospective purchase when buying as-is. The dealer knows the condition of the machinery, but only the purchaser knows the exact conditions under which it must function in the plant. Whoever makes the inspection should know how to operate the equipment, and what will be required of it. One must be capable of checking its fundamental condition.

A dealer will not guarantee the performance of a specific process. The company will attest to the present condition and functionality of the machinery but will not attempt to engineer it.

The inspection can be accomplished rather easily. The dealer will make the arrangements necessary for a visit, whether the equipment is in the dealer's warehouse or still at its original site.

Here are some basic inspection tips: First make sure the size, model, dimensions and specifications match the information being furnished by the dealer. Next, carefully check all moving parts, such as shafts, bearings, seals, drives and gears. These consumable parts are most subject to wear, and are normally replaced under any ongoing maintenance program. Any shortcomings should be reflected in the sales price.

If pressure is a significant operating factor, be sure that vessels, juice heaters, evaporators and similar equipment have been code stamped if this is required in your region. If necessary, the dealer should be able to arrange for a pressure test.

Also check the functioning of accessories that the machine depends on for proper operation. These include motors, starters and other electrical equipment, feeding or discharging mechanisms, and steam regulators.

If the machine is still installed in the original location, talk to people there who are familiar with it. Very often they can give you a good idea of the conditions under which it was operated, and of its present condition. They can inform as to whatever preventative maintenance has been performed on the machinery.

Don't rely entirely on first impressions. Many good, productive machines will look a lot worse than they actually are if allowed to stand idle for even a short time, especially in an industrial environment. An accumulation of dust or grime has no bearing on what service a machine will give. Make sure that machines that have been newly painted do not actually require extensive work.

So much used equipment is sold on location as-is because of savings in freight, handling and time. In most cases, the equipment can be bought on location at 50% of that of comparable new equipment, with reductions of up to 75% available. A stocking equipment dealer will often be glad to pass on any savings that the sale of a machine right from plant-site will afford them.

Purchasing on approval

Another popular method of buying equipment is "on approval." This option is the same as buying equipment as-is, except for a slight difference in approach. In this case, the dealer ships used equipment to prospective buyers who accept it with the privilege of inspecting the shipped equipment in detail at their plant. If the equipment proves satisfactory, the buyer pays for it; if it does not, then the buyer returns the equipment at no charge other than the cost of freight both ways, which in many cases is less than the cumulative costs of sending an inspector to look at a machine. Plus, the inspection can occur under controlled conditions at the buyer's mill.

This type of purchase is becoming more popular because if a machine is being offered at a location that is not close to the prospective buyer, it will take time and money to send an engineer to inspect it. Buying on approval avoids this expense. Certainly, this makes more sense with smaller items than with larger ones. Rejections are rare because dealers are extremely careful about what they ship out on approval. Also, if equipment has to be taken back, the dealers lose valuable selling time and run the risk of upsetting their clients.

Purchasing cleaned and tested

Today there is a growing trend to purchase used equipment "cleaned and tested." One reason is that the charge for this service is often only 5 to 10% more than that of equipment bought as-is. The cleaning and testing can be performed by most large dealer organizations at their own plant site. Dealers of used equipment also have a network of regional specialists throughout the world who can perform specialized machinery and fabrication services. These specialist firms are very efficient because this type of reconditioning is normally all that they do.

Purchasing rebuilt

The fourth method, that is buying equipment rebuilt, is the costliest option, but offers several advantages, normally including an extensive warranty. In the case of rebuilt equipment, the guarantee is against any mechanical defect, and is normally good for 90 to 120 days from shipment. In these cases, the cost is 30 to 50% higher than the cost of an as-is purchase. It is a good idea to select the right used-equipment dealer in these cases, since many of these firms have started specializing in rebuilding certain product lines and are likely to offer greater expertise in these areas. In any event, almost all used equipment dealers have developed extensive networks of specialized rebuilders to handle specific tasks.

Warranties

A word on warranties. Most large machinery dealers will stand behind their equipment when sold from stock, whether rebuilt or not. Warranties with rebuilt equipment are more formalized and extensive than those with equipment purchased as is, but a reputable dealer will stand behind any equipment sold from stock. This becomes more difficult when one plant sells directly to another or when a dealer arranges a sale directly from plant to plant, where warranties are not the norm, and where prices reflect this.

If there is a major defect, or the equipment requires replacement parts, this should be reflected in the purchase price. Further, if there is a defect that has escaped the inspections of both the dealer and the purchaser, the dealer should adjust the sales price to allow for the defect.

A reputable dealer operates pretty much like a manufacturer of new equipment in that both rely on repeat business for their long-term viability. The primary goal of either party is the ultimate satisfaction of the sugar producer.

Dealer services

Most large, reputable used machinery dealers offer a wide range of service which greatly enhance the efficacy of this market. These services include on-site inspections, administration of sales, dismantlement and shipping of equipment, sophisticated financial services including Letters of Credit and other sophisticated financial instruments, on-line computer accessibility, and extensive resource contacts into sub-specialties such as turnkey reinstallation, specialized reconditioning, and field testing of equipment.

Larger dealer organizations will take care of every aspect of dismantling and shipping. Some have in-house capability to do this, others will work through subcontractors. Most large dealers are conversant with local export and import customs policies.

Surplus equipment in your mill?

Another question faces the industry: What to do with the equipment left behind when a process is revamped or closed? In many cases, many people try to solve the problem by simply moving the piece of equipment out of the way, with the idea that "someday we'll have a use for it."

Too often that someday never comes, which is a particularly unfortunate situation since such idle assets cost money - for maintenance, security, insurance, property taxes, and storage space. There is also waste stemming from underutilized resources, since such assets can be converted to liquidity that can be used to purchase additional capital equipment.

One of the following actions can be undertaken with surplus equipment:

- Circulate a memo throughout your company announcing the availability of the equipment. In large companies, surplus equipment in one plant might be needed in another. Many companies, as a matter of policy, circulate lists of such equipment throughout the organization. In some companies, the purchasing division can get the equipment at book value. In other firms, where the autonomy of individual divisions is stressed and profit centers are observed, the transfer price is negotiated, as with any third party buyer or seller.

- Notify the company's Investment Recovery department. Some large companies have a department for liquidating surplus equipment - in essence, the firm acts as a dealer of used equipment. In these cases, company personnel are in the business of finding buyers for the equipment. This is often a good solution. But as in any business, inexperience can be costly, and there may not be enough volume in any single firm to make specialists out of those engaged in this activity.

- Call in a used equipment dealer. After a dealer has appraised the equipment, you generally have two choices. First, you can hire the dealer as a broker, in which case the company retains ownership of the equipment and the dealer earns a commission on the returns of the sale. The advantage to you, as a seller, is that you can set the sale price.

The alternative is to sell the equipment outright to the dealer, usually at lower selling price that what would have been set had the dealer been engaged as a broker. The lower price takes into account the shipping, insurance and tax costs that are now assumed by the dealer. Also taken into account is the dealer's element of risk (to find a suitable buyer) and profit requirements.

Risk Continuum

When selling secondhand process equipment, the selling company is faced with a risk continuum which places at the left-hand side (least risky) the outright sale of the equipment to a dealer and on the right-hand side (most risky) the consignment of the same equipment to a dealer for sale on a commission basis. The potential rewards on this continuum are inverted, with the left-hand, sell to dealer representing the least potential reward, and the right-hand, consign to dealer, representing the most potential reward.

For example, suppose a mill has a surplus centrifuge which is no longer needed. The mill can sell it to an equipment dealer for, say, $15,000 cash, or the same mill can decide to have the same machinery dealer sell this equipment on his behalf and net $25,000 to $30,000 The difference in the second example is that the proceeds may not be realized for 12 to 18 months, if at all. Of course, in either of these examples, the used machinery dealer will have invested a significant amount of money in the inspection, evaluation, and marketing of this equipment and will only make money once the equipment is sold.

The decision is X dollars now or (probably) X plus Y% dollars later.

A final decision on how to dispose of one's surplus assets depends greatly on one's current cash needs and risk strategy.

Although major dealers today have large trained organizations to sell their equipment, the element of risk is still present. Dealers maintain mailing lists of 80,000 potential buyers and sellers of equipment, lists that must constantly be improved, updated and revised.

A company may be able to find a buyer for an entire plant as an ongoing business. Such a sale would yield the best return on the sale of equipment. Unfortunately for those liquidating a plant, such occurrences are generally rare, only happening when a buyer can be found in an industrially developing nation. This is usually a long shot, and waiting for such a deal can tie up assets for months.

The alternative is to call in a dealer. Selling an entire plant is not much different from selling it in pieces. The dealer again may act as a broker or as a primary buyer. The major dealers do have the capital to purchase plants of almost any size, including the real estate (although that is not commonly the case). Thus, in just one transaction, the liquidating company can divest itself of an entire plant.

This document has been a brief overview of the specifics of buying and selling secondhand sugar process equipment. Different ways to buy have been discussed including as is, on approval, cleaned and tested and reconditioned or rebuilt. Various used equipment dealer services were discussed, including inspections, sales administration, dismantlement and shipping, financial services, computer accessibility and turnkey relocation. Finally, there was a brief discussion on the ways that a sugar producer can sell its own surplus process equipment.

VERTICAL CRYSTALLIZERS AT ENTERPRISE FACTORY

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ABSTRACT

Due to competition in the sugar industry today, sugar factories are having to increase efficiency and expand with limited space. Vertical crystallizers can certainly help with these two aspects. In 1995, a set of vertical crystallizers was installed at Enterprise factory. The vertical crystallizers were chosen over the older horizontal type because of limited space, knowledge of future expansion, and the idea of better exhaustion. Two massecuite pumps with variable speed drives were used to pump the massecuite into the bottom of the crystallizers. The massecuite flowed out of the top by gravity to the Stevens coil. The lower three quarters of the crystallizers were cooled with 110°F condenser water, running countercurrent to the massecuite flow. The upper quarter was used for reheating the massecuite. Water flow was controlled by using massecuite temperature. The design of the piping for massecuite and water changed over time as problems were encountered. The problems were mainly due to viscosity of the massecuite and channeling in the crystallizer. The report gives a brief description of the crystallizer setup, before and after modifications. Also given is a sequential order of problems encountered and solutions that seemed to work. Some recommendations are given at the end based on successful operation of the crystallizers during the 1996 crop.

INTRODUCTION

Vertical crystallizers were first used in the cane sugar industry in the early 1980's in the Far East and the Western Hemisphere (Chen and Chou, 1993). Several designs have emerged over the years, all with the intention of better exhaustion. Overall, the vertical crystallizers appear to offer more advantages than the horizontal type. Some advantages are lesser space requirements, fewer moving parts, and better exhaustion of molasses.

Until 1995, Enterprise factory had 15 horizontal U-type crystallizers with capacities totaling 16,000 cubic feet. One set of seven crystallizers was housed in one building, while another set of eight was housed in a different building. Each set of crystallizers fed a different battery of centrifugals. As the factory's grinding rate increased over the years, the crystallizer retention time became shorter. It was decided in early 1995 to install two vertical crystallizers, each with 7,500 cubic feet capacity. These two crystallizers were to run in series and feed one set of existing centrifugals. The two sets of old crystallizers were connected in series to feed the other set of centrifugals. The plumbing was designed to return to the original setup if any problems were encountered.

MATERIALS AND METHODS

The two vertical crystallizers are 7,500 cubic feet each. Both crystallizers have a hydraulic driven, ratchet-type drive for mixing. The mixing action is accomplished by long paddles sweeping between layers of horizontal coils. The coils are used to heat and cool the crystallizers. Various temperature probes are used to maintain the massecuite and water temperatures.

The original configuration (Figure 1) consisted of a 20 HP motor controlled by a variable frequency drive (VFD). This motor was coupled to a massecuite pump that pumped to the top of the #1 crystallizer. The VFD unit was controlled by the level of massecuite in the Stevens coil. The massecuite flowed from the bottom of the #1 crystallizer through an 18" crossover pipe into the bottom of the #2 crystallizer. The massecuite flowed out of the top of the #2 crystallizer into the Stevens coil. Coupled to the crossover pipe was another pump used to liquidate the crystallizers. Cooling was done in the first crystallizer and three quarters of the second. Reheating was done in the last quarter of the second. The cooling water was about 70°F and supplied by a well. The reheat water was about 130°F and was recirculated through a holding tank with a steam sparge. Both the heating and cooling water were piped to flow countercurrent to massecuite flow.

The final configuration (Figure 2) consisted of two 20 HP motors with VFDs controlled by the level of the Stevens coil. Each motor was coupled to a massecuite pump that fed into each crystallizer independently. Massecuite flowed into the bottom and out of the top of each crystallizer. The two streams from the crystallizers were then combined and fed into the Stevens coil. A small overflow of massecuite from the Stevens coil to the old crystallizers was monitored by use of a camera. This overflow was used as an indicator for consistent flow. Cooling was then done in the first two thirds of each vessel and heating was done in the last third of each vessel. Temperatures were taken on the massecuite only. The temperatures were used to control the cooling and reheating in the crystallizers. Water for cooling was then taken from the condenser water line at about 100°F. Reheat water was still taken from the original source. Two knife valves were added to the 18" pipe on either side of the liquidation line. The liquidation pump was kept in place.

RESULTS AND DISCUSSION

The 1995 crop began on September 28th. Later that day massecuite was pumped into the vertical crystallizers using 70°F cooling water in the coils. A few hours later the #1 crystallizer overflowed. The feed was slowed, and most of the massecuite was diverted to the old crystallizers. The cooling water was taken off, and hot water (~ 150°F) was introduced to lower the level in the first vessel. When the system leveled off, the crystallizers were run with little or no water in the coils. Seven days later massecuite temperatures were monitored, and cooling water was restored. A few hours later the #1 crystallizer overflowed. It was believed that the temperature of the cooling water was too low, thus causing the massecuite to solidify in the 18" crossover line. The two crystallizers were liquidated and steamed out to melt any sugar that might have hardened in the vessels. The crystallizers were refilled, and the 70°F cooling water was replaced with 110°F condenser water. Problems with overflowing still persisted, so a sonic pickup was installed at the top of the #1 vessel. This gave a warning when the massecuite was three to four feet from the point of overflowing. After two to three weeks both crystallizers were liquidated. A 30" insulated crossover line with a steam tracer was added to increase flow between the two crystallizers. After restarting the crystallizers, it was found that the massecuite was taking a path of least resistance and flowing through the 30" line. The 18" pipe was cold and solid. The massecuite also channeled through the 30" pipe, if the steam tracer was not used. If the steam tracer was used, it tended to melt some of the grain. Because of this and continuing high levels in the first vessel, the 30" pipe was removed and plans were made to run the crystallizers in parallel.

One of the major problems caused by the overflowing of the crystallizers was the massecuite flowing into the limit switches for the stirring device. As a result, the switches had to be reset on a number of occasions. When the limit switches quit working, this stopped the stirring device for the crystallizer. If the problem was discovered several hours later, the massecuite hardened slightly. When the hydraulic motors were restarted, the hardened massecuite put excessive strain on the hydraulic cylinders. This strain, along with the possible misalignment of the hydraulic cylinders, caused the cylinder pistons to leak or break off completely. At least four cylinders were changed due to these problems.

During the first part of November the two vessels were modified to run in parallel. The #2 vessel was filled first, while the #1 vessel was modified to run independently. Due to the inlet location, length of the agitation paddles, and temperature readings, we suspected channeling through the center of the crystallizer. It was assumed that insulating the bodies would help stop channeling, because the crystallizers were uncovered. However, channeling still occurred. Scrapers were attached to the paddles in the # 1 vessel to prevent coating on the walls. Large wing-like paddles were also installed to move massecuite from the center of the vessel. After the first body was put back on-line in late November, liquidation of the second body began. While steaming out the second body, the knife valve on the crossover line unseated and allowed massecuite to flow into that body. It was decided to finish the crop with just the #1 crystallizer and modify the second one in the off season.

The crystallizers were modified during the off season of 1996. The paddles and scrapers were installed in the second body. Another massecuite pump was installed to run both bodies independently. The limit switches for the stirring mechanism were replaced with proximity switches, and the misalignment of the cylinders was corrected. The crystallizers were started at the beginning of the 1996 crop and ran without complication.

The vertical crystallizers ran well during the 1996 crop. There was little analysis of massecuite and molasses done specifically on the vertical crystallizers. The two sets of crystallizers were sampled independently for the factory reports. These reports indicated an overall improvement in the performance of the vertical crystallizers. Some analyses are shown in Table 1.

A few points to consider about vertical crystallizers are:

- If used for C massecuite, running in parallel should be considered because of viscosities.
- Use as little pumping as possible to reduce breakage of sugar crystals.
- Design to reduce as much channeling as possible. Use insulation if needed, especially if crystallizers are outdoors.
- Approximately once a week the cooling water should be turned off to let everything heat up to massecuite temperature. This will dislodge and/or soften any sugar that has bridged and caused channeling.
- Monitor temperatures of massecuite in more than one place.

ACKNOWLEDGMENTS

The author would like to express appreciation to his colleagues, Christopher McGowen and Lisa Lopez, for their help in putting this paper together.

REFERENCES

1. Chen, J. C. P. And C. C. Chou. 1993 Cane Sugar Handbook, 12th. Ed. John Wiley and Sons, Inc., New York

Table 1. 1996 M.A.P. Nutsch Bomb Results

Thursday 10/31/96

Vertical Crystallizer #1		Vertical Crystallizer #2	
Massecuite	Molasses	Massecuite	Molasses
93.8 Bx	86.6 Bx	94.6 Bx	86.7 Bx
53.6 Pol	26.0 Pol	55.2 Pol	26.0 Pol
57.14 Pur	30.02 Pur	58.35 Pur	29.99 Pur

Monday 11/4/96

Vertical Crystallizer #1		Vertical Crystallizer #2	
Massecuite	Molasses	Massecuite	Molasses
94.8 Bx	90.8 Bx	95.0 Bx	90.6 Bx
53.2 Pol	26.0 Pol	54.0 Pol	27.2 Pol
56.12 Pur	28.63 Pur	56.84 Pur	30.02 Pur

Sunday 11/10/96

Vertical Crystallizer #1		Vertical Crystallizer #2	
Massecuite	Molasses	Massecuite	Molasses
94.4 Bx	85.0 Bx	94.4 Bx	91.8 Bx
53.6 Pol	24.8 Pol	52.4 Pol	28.0 Pol
56.78 Pur	29.18 Pur	55.51 Pur	30.5 Pur

Wednesday 11/13/96

From Receiver		Combined Vertical Crystallizers	
Massecuite	Molasses	Massecuite	Molasses
95.4 Bx	92.4 Bx	94.6 Bx	90.7 Bx
54.4 Pol	34.8 Pol	54.4 Pol	26.4 Pol
57.02 Pur	37.66 Pur	57.51 Pur	29.10 Pur

Saturday 11/16/96

From Receiver		Combined Vertical Crystallizers	
Massecuite	Molasses	Massecuite	Molasses
95.0 Bx	83.4 Bx	94.6 Bx	90.2 Bx
54.4 Pol	34.8 Pol	53.6 Pol	21.6 Pol
57.26 Pur	41.72 Pur	56.65 Pur	23.94 Pur

After M.A.P. Crystallizers	
Massecuite	Molasses
92.5 Bx	91.8 Bx
51.2 Pol	22.0 Pol
53.78 Pur	23.97 Pur

Sunday 11/24/96

From Receiver		Combined Vertical Crystallizers	
Massecuite	Molasses	Massecuite	Molasses
94.0 Bx	93.8 Bx	94.4 Bx	87.6 Bx
54.8 Pol	36.4 Pol	56.8 Pol	29.6 Pol
58.29 Pur	38.80 Pur	60.16 Pur	31.50 Pur

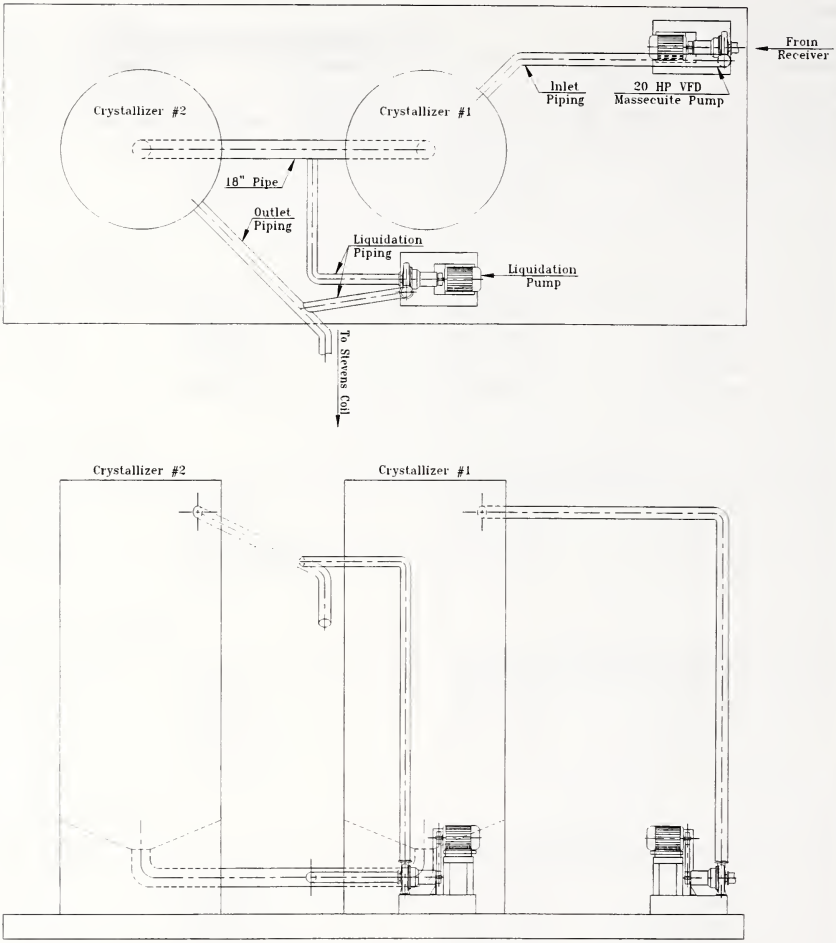

Figure 1
Original Configuration

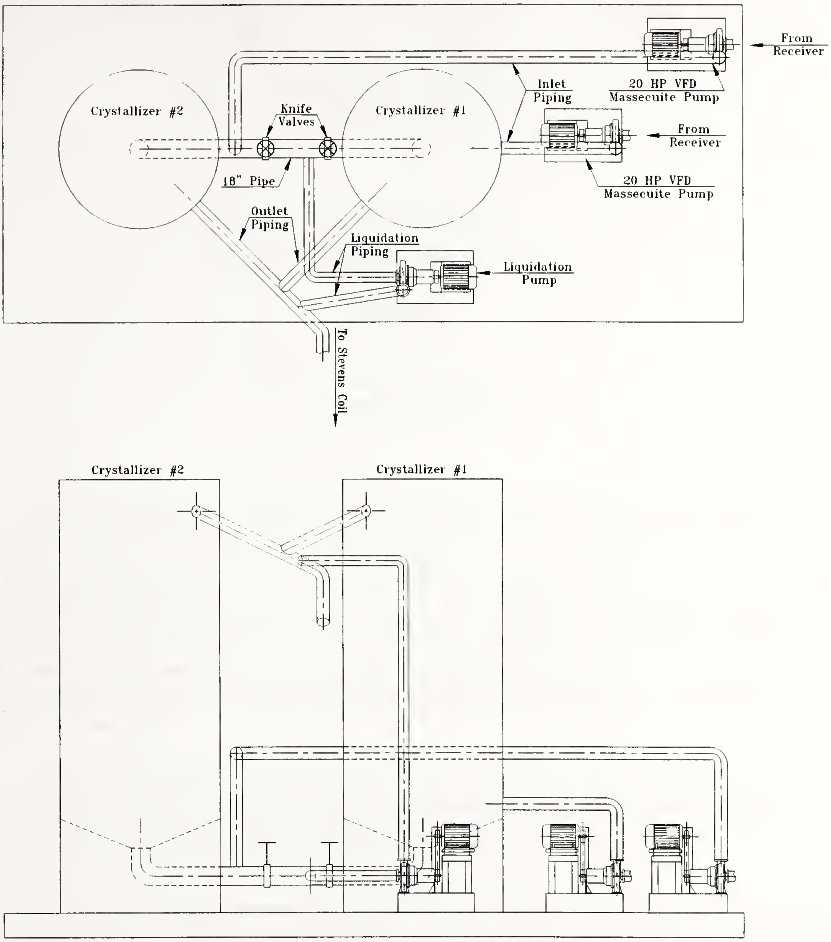

Figure 2
Final Configuration

CULTIVAR

RELEASE

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NOTICE OF RELEASE OF SUGARCANE CULTIVAR CP 89-1509

United States Department of Agriculture
Agricultural Research Service
Washington, D.C.

and

University of Florida
Institute of Food and Agricultural Sciences
Gainesville, Florida

and

Florida Sugar Cane League, Inc.
Clewiston, Florida

The U.S. Department of Agriculture, Agricultural Research Service, Washington, D.C.; the University of Florida, Institute of Food and Agricultural Sciences, Gainesville, Florida; and the Florida Sugar Cane League, Inc., Clewiston, Florida, working cooperatively to breed and select improved sugarcane cultivars, have jointly developed and hereby announce the release of a new cultivar, CP 89-1509. Scientists representing ARS in the cooperative breeding program were J.D. Miller and P.Y.P. Tai, Research Geneticists; B. Glaz, Research Agronomist; J.C. Comstock Research Plant Pathologist; representing the University of Florida, IFAS was L.Z. Liang, Biologist; and representing the Florida Sugar Cane League, Inc. was formerly J.M. Shine, Jr., Agronomist, now J. Follis, Crop Specialist.

CP 89-1509 stalks are light green under the leaf sheath and when exposed to the sun are brownish. Stalks have a prominent wax ring immediately below their nodes and the buds do not extend above the growth rings. Stalk weight of CP 89-1509 averaged 2.46 lbs per stalk compared to 2.25 lbs for CP 70-1133 and 2.86 lbs for CP 73-1547.

CP 89-1509 is being released for production only on sandy soils and was not evaluated on organic soils. CP 89-1509 had 10% higher average cane yields than CP 70-1133 and was essentially equal to the cane yield of CP 73-1547. Average sugar content in CP 89-1509 was 4% higher than CP 70-1133 and 7% higher than CP 73-1547. Average sugar yield for CP 89-1509 was 27% higher than CP 70-1133 but was only 9% higher than CP 73-1547.

CP 89-1509 has shown adequate resistance (for commercial production in Florida) to sugarcane mosaic virus, leaf scald, eye spot, smut, and rust. CP 89-1509 is susceptible to ratoon stunting disease. Surveys indicate that CP 89-1509 has a lower incidence of sugarcane yellow leaf virus than most current commercial cultivars. CP 89-1509 has a fiber content of 10.16% compared to 10.37% for CP 70-1133 and 9.44% for CP 73-1547.

Attached is a comparison of production for CP 89-1509 with two commercial checks, CP 70-1133 and CP 73-1547, in replicated yield trials over three crop cycles from 93/94 to 95/96 on sand soils.

Seedcane for commercial planting will be distributed by the Florida Sugar Cane League, Inc. in accordance with procedures to be announced to all sugarcane growers in Florida on or about October 1, 1998. Inquiries concerning seedcane should be directed to the Florida Sugar Cane League, Inc., P.O. Drawer 1208, Clewiston, Florida 33440. A small number of cuttings of CP 89-1509 for research purposes will be available for the next 5 years from the Sugarcane Field Station, HCR Box 8, Canal Point, FL 33438. It is requested that appropriate recognition of source be given when this germplasm contributes to research or development of a new breeding line or cultivar. Genetic material of this release will be deposited in the National Plant Germplasm System where it will be available for research purposes, including development and commercialization of new cultivars.

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HoCP 91-555, A NEW, HIGH YIELDING SUGARCANE VARIETY FOR LOUISIANA

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The Agricultural Research Service of the U.S. Department of Agriculture, the Louisiana Agricultural Experiment Station of the Louisiana State University Agricultural Center and the American Sugar Cane League of the U.S.A., Inc., working cooperatively to improve sugarcane cultivars, have jointly developed and hereby announce the release of a new cultivar, HoCP 91-555, for commercial planting in the fall of 1999. HoCP 91-555 is a product of the cross CP 83-644 X LCP 82-94 made at Canal Point (CP), Florida and selected at Houma (Ho), Louisiana, and has a high population of small size, green to brownish colored stalks. HoCP 91-555 is mostly erect in growth habit and suited to both whole-stalk "soldier" and combine harvesting. Yield data from a total of 44 mechanically harvested trials on both light- and heavy-textured soils indicate that HoCP 91-555 is similar to LCP 85-384, the leading commercial cultivar, in sugar per acre yields in plant-cane and first-stubble crops but significantly lower to LCP 85-384 in the second-stubble crop. However, HoCP 91-555 is similar to CP 70-321, the second leading commercial cultivar, in sugar per acre yields in the second-stubble crop. HoCP 91-555 is a high sucrose, early maturing cultivar with acceptable fiber content (13.3%). The cultivar is moderately resistant to sugarcane mosaic virus, is resistant to smut (*Ustilago scitaminea* Sydow) and is resistant to rust (*Puccinia melanocephala* H. and P. Syd.) under field conditions. The cultivar is susceptible to leaf scald [*Xanthomonas albilineans (Ashby*) Dowson] by artificial inoculation, but has shown adequate field resistance to natural infection. Ratoon stunting disease (*Clavibacter xyli* subsp. *xyli*) has caused significant reductions in yield of cane and total recoverable sugar per hectare of this cultivar in the stubble crops. Therefore, for HoCP 91-555 to yield up to its full potential, it is essential that plantings be made with seed cane free or nearly free of this disease. HoCP 91-555 is considered susceptible to the sugarcane borer (*Diatraea saccharalis* Fabricius). Seed cane will be distributed by the American Sugar Cane League on or after July 1999 and will be maintained at the Sugarcane Research Unit, USDA-ARS, SRRC, Houma, LA.

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AGRICULTURE ABSTRACTS

DISTRIBUTION OF THE LEAF SCALD PATHOGEN IN INFECTED SUGARCANE STALKS

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Polymerase chain reaction (PCR) and isolation on a semi-selective medium methods were used to study the within-stalk distribution pattern of the leaf scald bacterium, *Xanthomonas albilineans*. Xylem sap samples from every elongated internode (at least 1 cm in length) of 11 pairs of infected symptomatic vs. asymptomatic stalks were examined for *X. albilineans*. When internodes were grouped into upper, middle and lower thirds, no significant difference in mean percentage of detection was found between the two methods. *Xanthomonas albilineans* was detected by both methods in nearly every internode in the middle and lower thirds of symptomatic stalks. The mean percentages of detection in these two thirds of the symptomatic stalks were significantly higher than the mean percentage of detection in the upper third of the symptomatic stalks and in all the three sections of asymptomatic stalks. However, no significant differences were found among the mean percentages of detection for the three sections of asymptomatic stalks. This suggests that distribution of *X. albilineans* was random among internodes of asymptomatic stalks. It is recommended that as many as 20 stalks be collected across a field , where no leaf scald disease symptoms exist, and that a composite of xylem sap samples from six internodes per asymptomatic stalk, two randomly from each third, be used for diagnostic tests.

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EFFECT OF FALL FERTILIZER ON SUGARCANE YIELD ON A HEAVY TEXTURED SOIL

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Research has shown that fall fertilization can increase sugar yields in Louisiana for sugarcane (Saccharum spp.) grown on a light textured soil. The effect of fall fertilizer on sugarcane grown on heavy textured soils in Louisiana, however, has not been clearly defined. It has also been shown that incorporating gypsum and/or lime into soil prior to planting can result in higher sugarcane yields. Our research was conducted to determine if fall fertilizer, and placing lime under cane at planting versus mixing it into the soil, can increase sugarcane yields grown on a heavy textured soil. Results showed that fall fertilizer did not affect sugar yields for LCP 85-384 plant cane. However, adding N-P_2O_5-K_2O rates of 17-34-34, 17-68-68, and 17-68-136 kg/ha under cane at planting increased first-stubble sugar yields by 500, 740, and 660 kg/ha, respectively, while 17-17-17 and 34-34-34 fertilizer rates had no effect on sugar yields. Placing lime under cane at planting did not increase sugar yields compared to incorporating lime into the soil. Our results indicate that fall fertilization of sugarcane on a heavy textured soil can be a profitable practice for Louisiana sugarcane producers.

EFFECT OF FLOODING ON EFFICACY OF SOIL INSECTICIDES USED FOR WIREWORM CONTROL IN FLORIDA SUGARCANE

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The two soil insecticides most commonly used for wireworm control in Florida sugarcane are ethoprop applied as Mocap 20-G and phorate applied as Thimet 20-G. The objective of our research was to determine if the efficacy of these insecticides against the wireworm, *Melanotus communis*, is reduced after flooding since flooding due to excessive rainfall does occur in Florida sugarcane fields. Laboratory tests were conducted from 1996 to 1998. On a per volume basis of moist soil, seven times as much ethoprop or phorate was necessary to kill similar numbers of *M. communis* in muck versus sandy soil. Both insecticides retained efficacy against the wireworms, even after a seven day flood. At the rates used in our study, our data also showed that phorate killed more *M. communis* than ethoprop when granular formulations of these insecticides were used at equal rates.

ENVIRONMENTAL PARAMETERS AFFECTING CANE JUICE QUALITY

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Samples of cane juices across a Louisiana sugarcane factory's "cold lime" clarification process were collected during the 1996 grinding season. Sample collection was repeated seven times across the season. The last two sampling dates occurred at the end of the season, after freezing then warm weather conditions left the cane very deteriorated.

Samples were evaluated for their physico-chemical properties, using conventional factory analyses, and ion chromatography with pulsed amperometric detection was used to directly and accurately measure different sugar levels. Environmental (weather) data, including temperature and rainfall data for the whole season was also obtained.

The objective of this study was to investigate the correlations between environmental data and

chemical properties is described, as well as new environmental parameters which were found to have an effect. For example, the maximum temperature change in a 24 hour period during the week prior to sampling had a negative effect on the °Brix of the mixed juice. These results indicate that further work, which would include cane harvest and storage methods, is now required.

HERITABILITY OF PHOSPHORUS CONTENT IN SUGARCANE LEAVES

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Phosphorus reduction of EAA drainage water is one of several components of a comprehensive program aimed at sustaining remaining natural regions of the Everglades. Farmers in the Everglades Agricultural Area (EAA) must reduce the phosphorus content of their drainage water by at least 25% from a baseline mean calculated using 1978 through 1988 data. Sugarcane, the primary crop of the EAA, has been a good species for growers to work with to achieve phosphorus reductions because it requires low levels of phosphorus fertilizer for optimum growth. With the uses of best management practices in sugarcane and other crops, EAA farmers have already complied with phosphorus reductions scheduled to take effect in the year 2002. However, the legislation for these phosphorus reductions also states that more stringent reductions may be established after 2002. The purpose of this study was to approximate expected heritabilities in elite sugarcane (interspecific hybrids of *Saccharum* spp.) clones of leaf-tissue phosphorus. Previous work showed that elite sugarcane clones in Florida had various levels of leaf-tissue phosphorus concentrations. Samples were collected from 110 progeny of each of 10 crosses growing in the Seedling field at Canal Point. Preliminary heritability estimates suggest that progress in improving this characteristic is probable, but may be of a gradual, long-term nature. However, results with some crosses suggest that we may be able to devise strategies that result in moderate, short-term improvements. Increases in total phosphorus uptake of new sugarcane cultivars may supply EAA farmers and South Florida Water Management District managers a no-cost tool for their long-term strategy to reduce phosphorus in EAA drainage waters.

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REDUCING SUBSIDENCE OF ORGANIC SOILS IN THE EVERGLADES AGRICULTURAL AREA DURING THE PAST 19 YEARS

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The Everglades Agricultural Area (EAA) is a highly productive agricultural region. It produces 22% of the sugar produced in the U.S., several winter vegetables, rice, and sod. The organic soils of the EAA are the foundation of this agricultural productivity. For about 5,000 years prior to its drainage and conversion to an agricultural region, most of the organic soils in the EAA accreted at the rate of about 0.08 cm per year. Since drainage in the early part of this century, most of these soils have been subsiding at rates of 2.5 to 3.0 cm per year. Microbial oxidation is the primary cause of this soil loss. The rate of soil subsidence is directly related to water-table depth; the closer the water table is to the soil surface, the lower the rate of subsidence. From the early 1900s through 1978, the rate of soil subsidence was monitored on several subsidence lines. A recent study reported that the rate of subsidence in the EAA from 1978 through 1997 has decreased to 1.45 cm per year. Since 1978, about 27 cm of soil has been lost due to subsidence. However, had the subsidence rate continued at 2.54 cm per year, an additional 21 cm, or a total of 48 cm of soil would have been lost. Growers should be commended for this substantial soil conservation effort because much of it is due to their implementation of land forming and success at managing their crops under higher water tables. This reduced rate of soil subsidence not only prolongs agriculture in the EAA, but also has positive ecological implications. Further subsidence line surveys and organization of historical information are needed to better approximate current rates of subsidence. The reduced rate of subsidence supports the premise that long-term agronomic, microbiological, physiological, hydrological, and genetic research focussed on maintaining agricultural productivity and completely controlling subsidence can be successful.

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SUGARCANE YELLOW LEAF VIRUS STUDIES

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Sugarcane yellow leaf virus (ScYLV) occurs in association with the sugarcane yellow leaf syndrome in Florida and is apparently widespread throughout the industry. Research is presently underway to investigate whether or not the virus has a significant effect on sugarcane production in Florida. The intent is to compare infected and non-infected sugarcane with sugarcane that has been genetically engineered for resistance to ScYLV. Gene constructs designed to impart resistance to SCYLV are being developed (T. E. Mirkov, unpublished) and will be introduced into selected sugarcane varieties in Florida by biolistic transformation. However, sugarcane which is free of the virus will be needed. Five sugarcane varieties (CP 72-1210, CP 72-2086, CP 80-1743, CP 81-1384, and CP 84-1198) tested from a "disease-free" nursery in Homestead, FL, were all found to be infected with ScYLV by tissue-blot immunoassay (TBIA) or reverse transcriptase polymerase chain reaction (RT-PCR). Furthermore, callus cultures derived from infected sugarcane were found to be infected with the virus. A procedure developed to eliminate ScYLV from sugarcane by culturing apical meristems (P. Rott, unpublished) is now being used, and meristem cultures of 16 sugarcane varieties have thus far been established. Plants derived from apical meristem culture will be tested for ScYLV by RT-PCR, and plants found to be free of the virus will be used to establish a ScYLV-free nursery and callus cultures for genetic engineering and regeneration of genetically transformed sugarcane.

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THE EFFECTS OF NEMATODE AND *PYTHIUM* INTERRELATIONSHIPS ON SUGARCANE IN LOUISIANA

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A comprehensive nematode survey conducted from 1994 to the present has revealed large and diverse nematode communities in sugarcane fields. Comparisons of plant cane and ratoon crops indicate that nematode populations accumulate over time in successive ratoon crops. Nematode population levels were five times higher in third ratoon crops as compared to plant cane. Parasitism by *Criconemella*, *Helicotylenchus*, *Meloidogyne*, *Paratrichodorus*, *Pratylenchus*, *Trichodorus*, and *Tylenchorhynchus* has been documented in Louisiana sugarcane.

Greenhouse trials evaluated the susceptibility of major cultivars to nematode damage. Plants from single-node-cuttings were grown for 90 days in soil infested with 0, 1,000 or 4,000 nematodes (*Criconemella*, *Trichodorus*, and *Tylenchorhynchus* in equal proportions). Plant weights of CP 65-357, CP 70-321, CP 72-370, LCP 82-89, HoCP 85-845, LCP 85-384, and LCP 86-454 were significantly reduced 20 - 50% ($\underline{P} \leq 0.05$) by nematodes when compared to noninoculated controls.

Microplot experiments were conducted to evaluate the interrelationship between the host and nematodes under conditions more similar to the field. Cultivars CP 70-321 and LCP 82-89 were grown for 180 days in soil infested with 0, 1,200 or 12,000 nematodes (proportions same as greenhouse mixture). In 1995 and 1997, nematode damage significantly reduced ($\underline{P} \leq 0.05$) plant weights of LCP 82-89, but not CP 70-321. In 1996, nematodes significantly reduced ($\underline{P} \leq 0.05$) root weights of CP 70-321.

Interrelationships between *Pythium arrhenomanes* and these nematode species were evaluated under greenhouse conditions in 1996 and 1997. Steamed soil was infested with 0, 500, or 5,000 nematodes (40% *Criconemella*, 15% *Trichodorus*, and 45% *Tylenchorhynchus*) and/or 0, 22, or 220 g of fungal culture (V8 juice and vermiculite mixture containing oat seeds colonized by *P. arrhenomanes*) in all possible combinations. Individually, nematodes and *Pythium* caused reductions ($\underline{P} \leq 0.05$) in plant weights. Additionally, antagonistic nematode by *Pythium* interactions were observed regarding sugarcane yield and nematode reproduction.

USE OF A NITROGEN STABILIZATION PACKAGE TO INCREASE YIELDS AND REDUCE THE NITROGEN REQUIREMENTS OF SUGARCANE

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A study was initiated to determine the effect of a nitrogen stabilization package (N-hib Ca, composed of calcium chloride, magnesium chloride, and a urease inhibitor) and liquid urea, on yields and nitrogen fertilizer requirements of sugarcane *Saccharum spp.* hybrids. Urea and the nitrogen stabilization package were applied in all possible combinations in a 4x3 factorial (N rates were 0, 67, 134, and 201 kg N/ha; and calcium rates from the N stabilization package were 0, 22, and 44 kg Ca/ha) to a Baldwin silty clay (thermic vertic Ochraqualf) soil for four years. Adding 44 kg Ca/ha as N-hib Ca to 134 kg N/ha increased sugar yields by 2,950 kg/ha ($1531/ha at a sugar price of $0.519/kg) across the four year study, and reduced the nitrogen fertilizer requirement (by 67 kg N/ha each year) needed to obtain maximum yields. Use of N-hib Ca in a liquid urea fertilization program could, therefore, increase sugarcane yields and reduce environmental degradation resulting from nitrogen fertilization.

YELLOW LEAF SYNDROME IN FLORIDA: INCIDENCE AND RESISTANCE

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Previously, a high incidence of yellow leaf syndrome (YLS) was found in clones used for breeding at Canal Point. The objective was to determine how extensive YLS was in clones in different stages of our variety development program and to identify resistant clones. The incidence of luteovirus infection associated with YLS was determined in clones in the various selection stages of the Canal Point sugarcane variety development program using a serological leaf printing technique. Based on a single leaf per clone sampled, YLS incidences increased as the selection stage advanced at the Sugarcane Field Station (with no selection pressure for YLS resistance). The incidences were 1.6% of the 975 clones sampled in the seedling stage, 30.4% of the 425 clones sampled in Stage I,

38% of the 843 clones sampled in Stage II, 50% of the 128 clones sampled in Stage III. Eighty five percent of 41 recently released and commercial cultivars were infected with YLS at the Canal Point location. Similarly, a high YLS incidence was detected in 45 CP-clones sampled off station in a variety nursery. Some resistance to YLS is indicated since the incidence of YLS varied between the families sampled in Stage I border rows. Four families had an incidence below 12% where the overall average was much higher and one family was 100% infected. Variation among cultivars was also detected in YLS incidence. About two-thirds of the cultivars sampled at Canal Point and in the variety nursery off station had more than 90% of the plants infected, but CP 85-1308 had only 24% in the plot on the station and 10% in the variety nursery. Preliminary evidence indicates clones that have a lower YLS incidence share some common ancestors.

Journal American Society of Sugar Cane Technologists, Vol. 19, 1999

MANUFACTURING ABSTRACTS

VERTICAL CRYSTALLIZERS AT ENTERPRISE FACTORY

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Due to competition in the sugar industry today, sugar factories are having to increase efficiency and expand with limited space. Vertical crystallizers can certainly help with these two aspects. In 1995, a set of vertical crystallizers was installed at Enterprise factory. The vertical crystallizers were chosen over the older horizontal type because of limited space, knowledge of future expansion, and the idea of better exhaustion. Two massecuite pumps with variable speed drives were used to pump the massecuite into the bottom of the crystallizers. The massecuite flowed out of the top by gravity to the Stevens coil. The lower three quarters of the crystallizers were cooled with 110°F condenser water, running countercurrent to the massecuite flow. The upper quarter was used for reheating the massecuite. Water flow was controlled by using massecuite temperature. The design of the piping for massecuite and water changed over time as problems were encountered. The problems were mainly due to viscosity of the massecuite and channeling in the crystallizer. The report gives a brief description of the crystallizer setup, before and after modifications. Also given is a sequential order of problems encountered and solutions that seemed to work. Some recommendations are given at the end based on successful operation of the crystallizers during the 1996 crop.

AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS
EDITORIAL POLICY

Nature of papers to be published:

Papers submitted must represent a significant technological or scientific contribution. Papers will be limited to the production and processing of sugarcane, or to subjects logically related. Authors may submit papers that represent a review, a new approach to field or factory problems, or new knowledge gained through experimentation. Papers promoting machinery or commercial products will not be acceptable.

Frequency of publication:

The Journal will appear at least once a year. At the direction of the Joint Executive Committee, the Journal may appear more frequently. Contributed papers not presented at a meeting may be reviewed, edited, and published if the editorial criteria are met.

Editorial Committee:

The Editorial Committee shall be composed of the Managing Editor, Technical Editor for the Agricultural Section, and Technical Editor for the Manufacturing Section. The Editorial Committee shall regulate the Journal content and assure its quality. It is charged with the authority necessary to achieve these goals. The Editorial Committee shall determine broad policy. Each editor will serve for three years; and may at the Joint Executive Committee's discretion, serve beyond the expiration of his or her term.

Handling of manuscripts:

Four copies of each manuscript are initially submitted to the Managing Editor. Manuscripts received by the Managing Editor will be assigned a registration number determined serially by the date of receipt. The Managing Editor writes to the one who submitted the paper to inform the author of the receipt of the paper and the registration number which must be used in all correspondence regarding it.

The Technical Editors obtain at least two reviews for each paper from qualified persons. The identities of reviewers must not be revealed to each other nor to the author during the review process. Instructions sent with the papers emphasize the necessity for promptness as well as thoroughness in making the review. Page charges will be assessed for the entire manuscript for non-members. Members will be assessed for those pages in excess of ten (10) double spaced Times New Roman (TT) 12 pt typed pages of 8 1/2" x 11" dimension with one (1) inch margins.

When a paper is returned by reviewers, the Technical Editor evaluates the paper and the recommendations of the reviewers. If major revisions are recommended, the Technical Editor sends the paper to the author for this purpose, along with anonymous copies of reviewers' recommendations. When the paper is returned to the Technical Editor, he/she will judge the adequacy of the revision and may send the paper back to any reviewer for further review. When the paper has been revised satisfactorily, it is sent to the Managing Editor for publishing. A paper sent to its author for revision and held more than 6 months will be given a new date of receipt when returned. This date will determine the priority of publication of the paper.

A paper rejected by one reviewer may be sent to additional reviewers until two reviewers either accept or reject the paper. If a paper is judged by two or more reviewers as not acceptable for the Journal, theTechnical Editor returns it to the author along with a summary of the reasons given by the reviewers for the rejection. The registration form for the paper is filled out and returned to the Managing Editor along with copies of the reviewers' statements and a copy of the Technical Editor's transmittal letter to the author. The names of all reviewers must be shown on the registration form transmitted to the Managing Editor.

If the paper as received is recommended by two reviewers for publication in the Journal, it is read by the Technical Editor to correct typographical, grammatical, and style errors and to improve the writing where this seems possible and appropriate, with special care not to change the meaning. The paper is then sent by the Technical Editor to the Managing Editor who notifies the authors of the acceptance of the paper and of the probable dates of publication. At this time, the Managing Editor will request a final version in hardcopy and on diskette in WordPerfect format from the corresponding author.

Preparation of papers for publication:

Papers sent by the Technical Editor to the Managing Editor are prepared for printing according to their dates of original submittal and final approval and according to the space available in the next issue of the Journal.

The paper is printed in the proper form for reproduction, and proofs are sent to the authors for final review. When the proofs are returned, all necessary corrections are made prior to reproduction. The author will be notified at the appropriate time to order reprints at cost.

Any drawings and photographs for the figures in the paper are "scaled" according to their dimensions, the size of lettering, and other factors. They are then sent to the printer for camera work. Proofs of the illustrations are sent to the authors. Any changes requested at this stage would be expensive and authors will be expected to pay the cost of such changes.

Reprinting in trade journals has the approval of the Editorial Committee provided: a) no article is reprinted before being accepted by the Journal; b) credit is given all authors, the author's institutions, and the ASSCT; and c) permission of all authors has been obtained. Summaries, condensations, or portions may be printed in advance of Journal publication provided the approval of the Editorial Committee has been obtained.

RULES FOR PREPARING PAPERS TO BE PRINTED IN THE JOURNAL OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

Format

Unless the nature of the manuscript prevents, it should include the following sections in the order listed: ABSTRACT, INTRODUCTION, MATERIALS and METHODS, RESULTS, DISCUSSION (OR RESULTS AND DISCUSSION), CONCLUSIONS, ACKNOWLEDGMENTS, and REFERENCES. Not all the sections listed above will be included in each paper, but each section should have an appropriate heading that is centered on the page with all letters capitalized. Scientific names shall be italicized.

All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. If using WordPerfect, set the bottom margin at 0.5 inches. This will set the page number at 0.5 inches and the final line of text at 1 inch from the bottom margin. Exactness in reproduction can be insured if electronic copies of the final versions of manuscripts are submitted. Authors are encouraged to contact the managing editor for specifics regarding software and formatting software to achieve ease of electronic transfer.

Authorship

Name of the authors, institution or organization with which they are associated, and their locations should follow the title of the paper.

Abstract

The abstract should be placed at the beginning of the manuscript, immediately following the author's name, organization and location.

Tables

Number the tables consecutively and refer to them in the text as Table 1, Table 2, etc. Each table must have a heading or caption. Capitalize only the initial word and proper names in table headings. Headings and text of tables should be single spaced. Use TAB function rather than SPACE BAR to separate columns of a table.

Figures

Number the figures consecutively and refer to them in the text as Figure 1, Figure 2, etc. Each figure must have a legend. Figures must be of sufficient quality to reproduce legibly.

Drawings & Photographs

Drawings and photographs must be provided separately from the text of the manuscript and identified on the back of each. Type figure numbers and legends on separate pieces of paper with proper identification. Drawings and photographs should be of sufficient quality that they will reproduce legibly.

Reference Citations

The heading for the literature cited should be REFERENCES. References should be arranged such that the literature cited will be numbered consecutively and placed in alphabetical order according to the surname of the senior author. In the text, references to literature cited should be made by name of author(s) and year of publication from list of references. Do not use capital letters in the titles of such articles except in initial words and proper names, but capitalize words in the titles of the periodicals or books.

Format Example

ITCHGRASS *(ROTTBOELLIA COCHINCHINENSIS)* CONTROL IN SUGARCANE WITH POSTEMERGENCE HERBICIDES

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ABSTRACT

INTRODUCTION

MATERIALS AND METHODS

RESULTS AND DISCUSSION

Table 1. Visual itchgrass control and sugarcane injury as influenced by over-the-top herbicide application at Maringouin and Thibodaux, LA, 1989.

CONCLUSIONS

ACKNOWLEDGMENTS

REFERENCES

GUIDELINES FOR PREPARING PAPERS FOR JOURNAL OF ASSCT

The following guidelines for WordPerfect software are intended to facilitate the production of this journal. Authors are strongly encouraged to prepare their final manuscripts with WordPerfect 6.0 or a later version for Windows. Please contact the Managing Editor if you will not use one of those software packages.

Paper & Margins: All material (including tables and figures) shall be submitted on 8½ X 11 inch paper with one inch margins on all sides. To achieve this with WordPerfect, set the top, left, and right margins at one inch. However, set the bottom margin at 0.5 inches. This will place the page number at 0.5 inches and the final line of text at one inch.

Fonts: Submit your document in the Times New Roman (TT) 12pt font. If you do not have this font, contact the Managing Editor.

Alignment: Choose the full alignment option to prepare your manuscript. The use of SPACE BAR for alignment is not acceptable. As a general rule SPACE BAR should only be used for space between words and limited other uses. Do not use space bar to indent paragraphs, align and indent columns, or create tables.

Do not use hard returns at the end of sentences within a paragraph. Hard returns are to be used when ending paragraphs or producing a short line.

Place tables and figures within the text where you wish them to appear. Otherwise, all tables and figures will appear after your References section.

Styles: ***Italicize*** scientific names. Do not use underline.

Tables: Use Tab stops and the **Graphics** line draw option when constructing tables. Avoid the space bar to separate columns (see alignment). All lines should begin with the left most symbol in their left most column and should end with the right most symbol in their right most column.

Citations: When producing Literature Citations, use the indent feature to produce text as below.

1. Smith, I. M., H. P. Jones, C. W. Doe, 1991. The use of multidiscipline approaches to control rodent populations in plants. Journal of American Society of Plant Management. 10:383-394.

CONSTITUTION OF THE AMERICAN SOCIETY OF SUGAR CANE TECHNOLOGISTS

As Revised and Approved on June 21, 1991
As Amended on June 23, 1994
As Amended on June 15, 1995

ARTICLE I

Name, Object and Domicile

Section 1. The name of this Society shall be the American Society of Sugar Cane Technolo-gists.

Section 2. The object of this society shall be the general study of the sugar industry in all its various branches and the dissemination of information to the members of the organization through meetings and publications.

Section 3. The domicile of the Society shall be at the office of the General Secretary-Treasurer (as described in Article IV, Section 1).

ARTICLE II

Divisions

The Society shall be composed of two divisions, the Louisiana Division and the Florida Division. Each division shall have its separate membership roster and separate officers and committees. Voting rights of active and honorary members shall be restricted to their respective divisions, except at the general annual and special meetings of the entire Society, hereinafter provided for, at which general meetings active and honorary members of both divisions shall have the right to vote. Officers and committee members shall be members of and serve the respective divisions from which elected or selected, except the General Secretary-Treasurer who shall serve the entire Society.

ARTICLE III

Membership and Dues

Section 1. There shall be five classes of members: Active, Associate, Honorary, Off-shore or Foreign, and Supporting.

Section 2. Active members shall be individuals residing in the continental United States actually engaged in the production of sugar cane or the manufacture of cane sugar, or research or education pertaining to the industry, including employees of any corporation, firm or other organization which is so engaged.

Section 3. Associate members shall be individuals not actively engaged in the production of sugar cane or the manufacture of cane sugar or research pertaining to the industry, but who may be interested in the objects of the Society.

Section 4. Honorary membership shall be conferred on any individual who has distinguished himself or herself in the sugar industry, and has been elected by a majority vote of the Joint Executive Committee. Honorary membership shall be exempt from dues and entitled to all the privileges of active membership. Each Division may have up to 15 living Honorary Members. In addition, there may be up to 5 living Honorary members assigned to the two Divisions jointly.

Section 5. Off-shore or foreign members shall be individuals not residing in the continental United States who may be interested in the objects of the Society.

Section 6. Supporting members shall be persons engaged in the manufacturing, production or distribution of equipment or supplies used in conjunction with production of sugar cane or cane sugar, or any corporation, firm or other organization engaged in the production of sugar cane or the manufacture of cane sugar, who may be interested in the objects of the Society.

Section 7. Applicants for new membership shall make written application to the Secretary-Treasurer of the respective divisions, endorsed by two members of the division, and such applications shall be acted upon by the division membership committee.

Section 8. Minimum charge for annual dues shall be as follows:

Active Membership	$10.00
Associate Membership	$25.00
Honorary Membership	NONE
Off-shore or Foreign Membership	$20.00
Supporting Membership	$50.00

Each Division can assess charges for dues more than the above schedule as determined by the Division officers or by the membership at the discretion of the officers of each Division.

Dues for each calendar year shall be paid not later than 3 months prior to the annual meeting of the member's division. New members shall pay the full amount of dues, irrespective of when they join. Any changes in dues will become effective in the subsequent calendar year.

Section 9. Dues shall be collected by each of the Division's Secretary-Treasurer from the members in their respective divisions. Unless and until changed by action of the Joint Executive Committee, 50 percent of the minimum charge for annual dues, as described in Section 8 for each membership class, shall be transmitted to the office of the General Secretary-Treasurer.

Section 10. Members in arrears for dues for more than a year will be dropped from membership after thirty days notice to this effect from the Secretary-Treasurer. Members thus dropped may be reinstated only after payment of back dues and assessments.

Section 11. Only active members of the Society whose dues are not in arrears and honorary members shall have the privilege of voting and holding office. Only members (all classes) shall have the privilege of speaking at meetings of the Society.

ARTICLE IV

General Secretary-Treasurer and Joint Executive Committee

Section 1. The General Secretary-Treasurer shall serve as Chief Administrative Officer of the Society and shall coordinate the activities of the divisions and the sections. He or she will serve as ex-officio Chairperson of the Joint Executive Committee and as General Chairperson of the General Society Meetings, and shall have such other duties as may be delegated to him or her by the Joint Executive Committee. The office of the General Secretary-Treasurer shall be the domicile of the Society.

Section 2. The Joint Executive Committee shall be composed of the elected members of the two division Executive Committees, and is vested with full authority to conduct the business and affairs of the Society.

ARTICLE V

Division Officers and Executive Committee

Section 1. The officers of each division of the Society shall be: a President, a First Vice-President, a Second Vice-President, a Secretary-Treasurer or a Secretary and a Treasurer, and an Executive Committee composed of these officers and four other members, one from each section of the Division (as described in Section 3 of Article VII), one elected at large, and the President of the previous Executive Committee who shall serve as an Ex-Officio member of the Division Executive Committee. The office of the Secretary-Treasurer in this constitution indicates either the Secretary-Treasurer, or the Secretary and the Treasurer.

Section 2. These officers, except Secretary-Treasurer, shall be nominated by a nominating committee and voted upon before the annual division meeting. Notices of such nominations shall be mailed to each member at least one month before such meeting. Ballots not received before the annually specified date will not be counted.

Section 3. The Secretary-Treasurer shall be appointed by and serve as a non-voting member at the pleasure of the Division Executive Committee. The Secretary-Treasurer may not hold an elected office on the Executive Committee.

Section 4. The duties of these officers shall be such as usually pertain to such officers in similar societies.

Section 5. Each section as described in Article VII shall be represented in the offices of the President and Vice-President.

Section 6. The President, First Vice-President, and Second Vice-President of each Division shall not hold the same office for two consecutive years. Either Section Chairperson (as described in Section 3 of Article VII) may hold the same office for up to two consecutive years. The terms of the other officers shall be unlimited.

Section 7. The President shall be elected each year alternately from the two sections hereinafter provided for. In any given year, the Presidents of the two Divisions shall be nominated and elected from different sections. The President from the Louisiana Division for the year beginning February, 1970, shall be nominated and elected from the Agricultural Section. The president from the Florida Division for the year beginning February, 1970, shall be nominated and elected from the Manufacturing Section.

Section 8. Vacancies occurring between meetings shall be filled by the Division Executive Committee.

Section 9. The terms "year" and "consecutive year" as used in Articles V and VI shall be considered to be comprised of the elapsed time between one annual division meeting of the Society and the following annual division meeting of the Society.

ARTICLE VI

Division Committees

Section 1. The President of each division shall appoint a committee of three to serve as a Membership Committee. It will be the duty of this committee to pass upon applications for membership in the division and report to the Secretary-Treasurer.

Section 2. The President of each division shall appoint each year a committee of three to serve as a Nominating Committee. It will be the duty of the Secretary-Treasurer of the Division to notify all active and honorary members of the Division as to the personnel of this committee. It will be the duty of this committee to receive nominations and to prepare a list of nominees and mail this to each member of the Division at least a month before the annual meeting.

ARTICLE VII

Sections

Section 1. There shall be two sections of each Division, to be designated as:

1. Agricultural
2. Manufacturing

Section 2. Each active member shall designate whether he or she desires to be enrolled in the Agricultural Section or the Manufacturing Section.

Section 3. There shall be a Chairperson for each section of each Division who will be the member from that Section elected to the Executive Committee. It will be the duty of the Chairperson of a section to arrange the program for the annual Division meeting.

Section 4. The Executive Committee of each Division is empowered to elect one of their own number or to appoint another person to handle the details of printing, proof reading, etc., in connection with these programs and to authorize the Secretary-Treasurer to make whatever payments may be necessary for same.

ARTICLE VIII

Meetings

Section 1. The annual General Meeting of the members of the Society shall be held in June each year on a date and at a place to be determined, from time to time, by the Joint Executive Committee. At all meetings of the two Divisions of the Society, five percent of the active members shall constitute a quorum. The program for the annual meeting of the Society shall be arranged by the General Secretary-Treasurer in collaboration with the Joint Executive Committee.

Section 2. The annual meeting of the Louisiana Division shall be held in February of each year, at such time as the Executive Committee of the Division shall decide. The annual meeting of the Florida Division shall be held in September or October of each year, at such time as the Executive Committee of that Division shall decide. Special meetings of a Division may be called by the Executive Committee of such Division.

Section 3. Special meetings of a Section for the discussion of matters of particular interest to that Section may be called by the President upon request from the respective Chairperson of a Section.

Section 4. At Division meetings, 10 percent of the active division members and the President or a Vice-President shall constitute a quorum.

ARTICLE IX

Management

Section 1. The conduct and management of the affairs of the Society and of the Divisions including the direction of work of its special committees, shall be in the hands of the Joint Executive Committee and Division Executive Committees, respectively.

Section 2. The Joint Executive Committee shall represent this Society in conferences with the American Sugar Cane League, the Florida Sugar Cane League, or any other association, and may make any rules or conduct any business not in conflict with this Constitution.

Section 3. Four members of the Division Executive Committee shall constitute a quorum. The President, or in his or her absence one of the Vice-Presidents, shall chair this committee.

Section 4. Two members of each Division Executive Committee shall constitute a quorum of all members of the Joint Executive Committee. Each member of the Joint Executive Committee, except the General Secretary-Treasurer, shall be entitled to one vote on all matters voted upon by the Joint Executive Committee. In case of a tie vote, the General Secretary-Treasurer shall cast the deciding vote.

ARTICLE X

Publications

Section 1. The name of the official journal of the Society shall be the "Journal of the American Society of Sugar Cane Technologists." This Journal shall be published at least once per calendar year. All articles, whether volunteered or invited, shall be subject to review as described in Section 4 of Article X.

Section 2. The Managing Editor of the Journal of the American Society of Sugar Cane Technologists shall be a member of either the Florida or Louisiana Divisions; however, he or she shall not be a member of both Divisions. The Division affiliation of Managing Editors shall alternate between the Divisions from term to term with the normal term being three years, unless the Division responsible for nominating the new Managing Editor reports that it has no suitable candidate. The Managing Editor shall be appointed by the Joint Executive Committee no later than 6 months prior to the beginning of his or her term. A term will coincide with the date of the annual Joint Meeting of the Society. No one shall serve two consecutive terms unless there is no suitable candidate from either Division willing to replace the current Managing Editor. If the Managing Editor serves less than one year of his or her three-year term, another candidate is nominated by the same Division, approved by the other Division, and appointed by the General Secretary-Treasurer to a full three-year term. If the appointed Managing Editor serves more than one year but less than the full three-year term, the Technical Editor from the same Division will fill the unexpired term of the departed Managing Editor. In the event that the Technical Editor declines the nomination, the General Secretary-Treasurer will appoint a Managing Editor from the same Division to serve the unexpired term.

Section 3. The "Journal of the American Society of Sugar Cane Technologists" shall have two Technical Editors, which are an Agricultural Editor and a Manufacturing Editor. The Managing Editor shall appoint the Technical Editors for terms not to exceed his or her term of office. Any Technical Editor shall be a member of either the Louisiana or Florida Division. Each Division will be represented by one technical editor at all times unless the Executive Committee of one Division and the Managing Editor agree that there is no suitable candidate willing to serve from that Division.

Section 4. Any member or nonmember wishing to contribute to the Journal of the American Society of Sugar Cane Technologists shall submit his or her manuscript to the Managing Editor. The Managing Editor shall then assign the manuscript to the appropriate Technical Editor. The Technical Editor shall solicit peer reviews until, in the opinion of the Technical Editor, two responsible reviews have been obtained that either accept (with or without major or minor revision) or reject the manuscript. For articles accepted with major revision, it shall be the responsibility of the Technical Editor to decide if the authors have satisfactorily completed the major revision(s). The Technical Editor may solicit the opinion of the reviewers when making this decision. The Technical Editors shall not divulge the identity of any reviewer. The Managing Editor shall serve as Technical Editor of any manuscript which includes a Technical Editor as an author.

ARTICLE XI

Amendments

Section 1. Amendments to this Constitution may be made only at the annual meeting of the Society or at a special meeting of the Society. Written notices of such proposed amendments, accompanied by the signature of at least twenty (20) active or honorary members must be given to the General Secretary-Treasurer at least thirty (30) days before the date of the meeting, and he or she must notify each member of the proposed amendment before the date of the meeting.

ARTICLE XII

Dissolution

Section 1. All members must receive notification from the General Secretary-Treasurer of any meeting called for the purpose of terminating the Society at least thirty (30) days prior to the date of the meeting. After all members have been properly notified, this organization may be terminated at any time, at any regular or special meeting called for that purpose, by an affirmative vote of two-thirds of the total honorary and active members in good standing present at the meeting. Thereupon, the organization shall be dissolved by such legal proceedings as are provided by law. Upon dissolution of the Joint Society, its assets will be divided equally between the two Divisions of the Society. Dissolution of the Joint Society will not be cause for automatic dissolution of either Division. Upon dissolution of either Division, its assets will be divided in accordance with the wishes of its members and in conformity with existing IRS regulations and other laws applicable at the time of dissolution.

ARTICLE XIII

Assets

Section 1. No member shall have any vested right, interest or privilege of, in, or to the assets, functions, affairs or franchises of the organization; nor any right, interest or privilege which may be transferable or inheritable.

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